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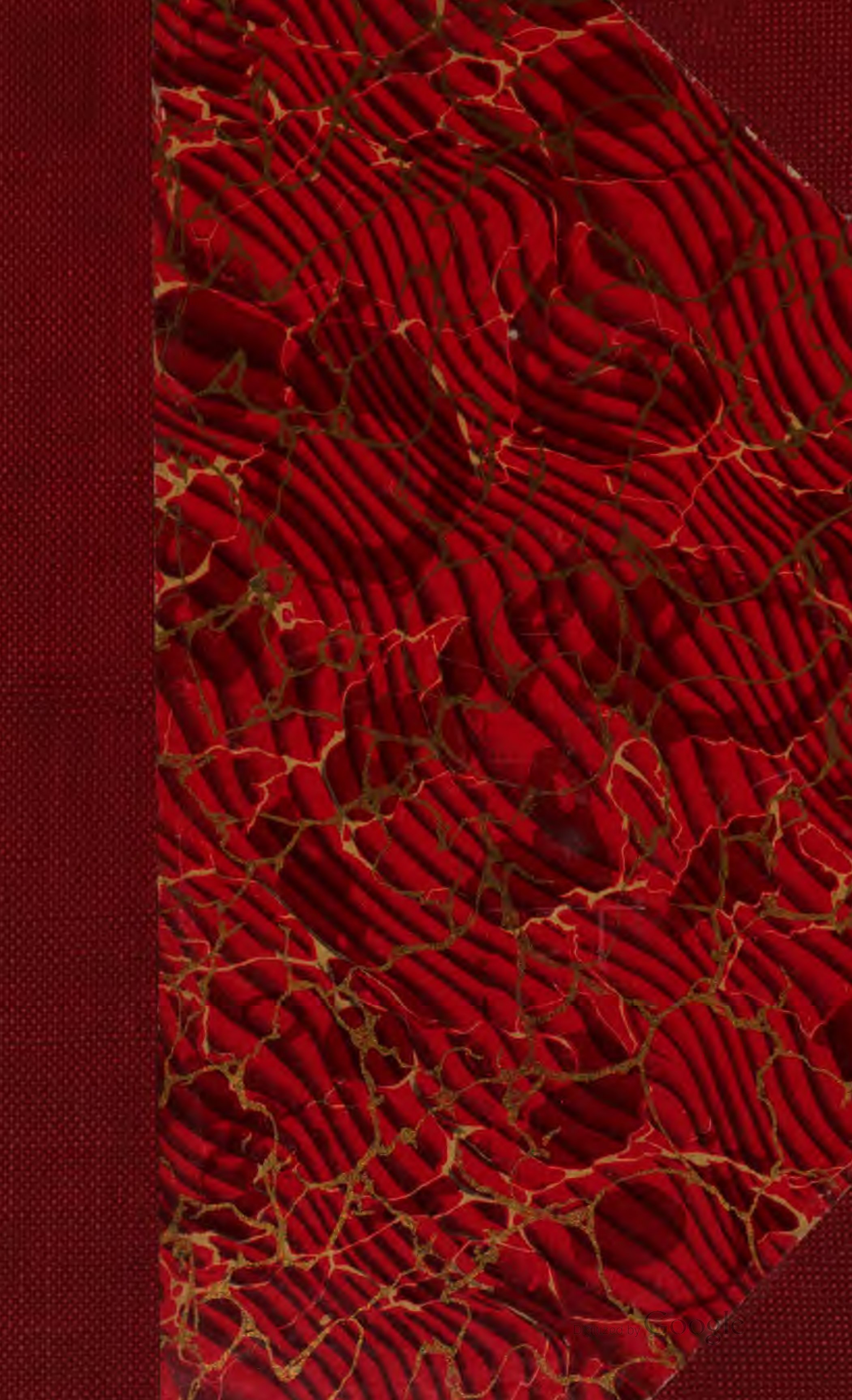

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 66.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 66.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

I. THE ASPARAGUS MINER.
NOTES ON THE ASPARAGUS BEETLES.

By **F. H. CHITTENDEN**, *Entomologist in Charge of Breeding Experiments.*

II. THE WATER-CRESS SOWBUG.
THE WATER-CRESS LEAF-BEETLE.

By **F. H. CHITTENDEN**, *Entomologist in Charge of Breeding Experiments.*

III. THE CRANBERRY SPANWORM.
THE STRIPED GARDEN CATERPILLAR.

By **F. H. CHITTENDEN**, *Entomologist in Charge of Breeding Experiments.*

IV. THE LEAFHOPPERS OF THE SUGAR BEET AND THEIR RELATION TO THE "CURLY-LEAF" CONDITION.

By **E. D. BALL**, Ph. D., *Special Field Agent.*

V. THE SEMITROPICAL ARMY WORM.

By **F. H. CHITTENDEN** and **H. M. RUSSELL.**

VI. THE HOP FLEA-BEETLE.

By **F. H. CHITTENDEN**, Sc. D., *in Charge of Truck Crop and Special Insect Investigations.*

VII. MISCELLANEOUS NOTES ON TRUCK-CROP INSECTS.

By **F. H. CHITTENDEN**, Sc. D., *in Charge of Truck Crop and Stored Product Insect Investigations.*

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BUREAU OF ENTOMOLOGY.

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F. H. **Chittenden**, *in charge.*

H. M. **Russell**, C. H. **Popenoe**, D. K. **McMillan**, H. O. **Marsh**, E. G. **Smyth**, **Thos.** H. **Jones**, *agents and experts.*
E. D. **Ball**,[a] *special field agent.*
E. G. **Titus**,[a] I. J. **Condit**, H. S. **Heller**,[b] W. B. **Parker**, *collaborators.*

---

[a] Resigned June 30, 1909. [b] Resigned January 31, 1910.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., January 25, 1910.

Sir: I have the honor to transmit herewith, for publication as Bulletin No. 66, seven papers dealing with certain insects injurious to truck crops. These papers, which were issued separately during the years 1907 and 1909, are as follows: The Asparagus Miner and Notes on the Asparagus Beetles, by F. H. Chittenden; The Water-Cress Sowbug and the Water-Cress Leaf-Beetle, by F. H. Chittenden; The Cranberry Spanworm and the Striped Garden Caterpillar, by F. H. Chittenden; The Leafhoppers of the Sugar Beet and Their Relation to the "Curly-Leaf" Condition, by E. D. Ball; The Semi-tropical Army Worm, by F. H. Chittenden and H. M. Russell; The Hop Flea-Beetle, by F. H. Chittenden; Miscellaneous Notes on Truck-Crop Insects, by F. H. Chittenden.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

PREFACE.

The present publication comprises a series of articles which have been issued in seven parts and are now brought together as a single bulletin. It relates to a line of investigations begun in 1896, the earlier results of which were published in previous bulletins of the present series, in Yearbooks of the Department, and in circulars of the Bureau. The title, "Some Insects Injurious to Truck Crops," is used in a wide sense and includes insects injurious to sugar beet, since the same classes of insects which affect this important crop also attack table beets and spinach.

The initial article is the first treatment that has been given to the asparagus miner in a Government publication. The second article, entitled "Notes on the asparagus beetles," is a sequel to a general article on the asparagus beetles which appeared in the Yearbook for 1896. It places on record all important new localities to date, and furnishes similarly the latest information in regard to remedies. The importance which has been assumed by the water-cress sowbug since 1902 has necessitated the preparation of a publication covering this species, with suggestions for its control. The subject of water-cress insects has never been considered in a Department publication hitherto, and similar treatment of the water-cress leaf-beetle to that furnished on the sowbug follows. The cranberry spanworm is given monographic treatment not hitherto furnished for it. It is an omnivorous feeder, and has attracted attention on various crops, and especially on asparagus and strawberry. A similar article on the striped garden caterpillar, also an omnivorous form, completes Part III of the bulletin.

The article representing Part IV is a detailed consideration of the sugar-beet leafhopper and of other affiliated species in their relation to the "curly-leaf" condition of the sugar beet. It was prepared by Dr. E. D. Ball, while special field agent of this Bureau in Utah; he has been engaged on this work for a number of years. The semi-tropical army worm is the subject of Part V. It was the most troublesome insect on truck crops in Florida during 1907, and was given detailed study from every possible standpoint by the authors. In the experiments with remedies, which were conducted by the junior author, Mr. H. M. Russell, a series of 15 trials was performed, proving that a spray of arsenate of lead is far superior to Paris green under local conditions. The final article of the series, entitled "The hop flea-beetle," has been a subject of study for a number of years. Its treatment is monographic to date, and, while some of the data furnished are preliminary in character, it will constitute a basis for future work on the same species. This insect is given the name of flea-beetle because of the local name, "hop flea," used in the hop-growing region of the Pacific coast, but it is also a pest in sugar-beet fields and injurious to rhubarb, radishes, and other truck crops. In the preparation of the article the writer has been fortunate in obtaining the cooperation of various experts, including, particularly, Messrs. H. J. Quayle and Theodor Eder.

Following this article are a few miscellaneous notes on truck-crop insects, the first two giving additional information in regard to the principal asparagus pests treated in Part I, the last furnishing additional observations on the water-cress insects treated in Part II, with notes on the first injurious occurrence of the destructive pea moth and of a western root-maggot in the United States.

F. H. CHITTENDEN.

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[a] The seven papers constituting this bulletin were issued in separate form on March 16, April 23, and August 31, 1907, and on January 27, January 28, May 8, and July 19, 1909, respectively.

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ERRATA.

Page 2, line 19, for *1861* read *1869*.
Page 2, footnote [a], for *160* read *46*.
Page 18, line 11, for *1893* read *1903*.
Page 18, line 22, for *letter* read *latter*.
Page 65, line 15 from bottom, for *fresh air-slaked* read *freshly slaked*.
Page 68, line 8, for *6* read *50*.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 66, Part I.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE ASPARAGUS MINER.
NOTES ON THE ASPARAGUS BEETLES.

BY

F. H. CHITTENDEN,
Entomologist in Charge of Breeding Experiments.

ISSUED MARCH 16, 1907.

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Fig. 1. *Agromyza simplex:* Fly 1
  2. *Agromyza simplex:* Larva, pupa, work 2

U. S. D. A., B. E. Bul. 66, Part I. Issued March 16, 1907.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE ASPARAGUS MINER.

(*Agromyza simplex* Loew.)

The stalks of asparagus are frequently attacked by insects, and in recent years have been reported considerably injured by the larva or maggot of a minute black fly to which the name asparagus miner has been given. The larva mines under the epidermis of the stalk, and when it has transformed to the puparium or "flaxseed" stage the thin outer skin becomes more or less ruptured and the presence of the insect is easily detected. It operates more abundantly near the base of the stalks and penetrates below the surface of the ground to a depth of 7 or 8 inches. During the year 1906 this species attracted considerable attention by its abundance in some of the principal asparagus-growing sections of New England and it bids fair to become a pest of considerable importance. It was first noticed on asparagus in 1896, ten years earlier than the present writing, prior to which time nothing was known of its habits. It is a native species and evidently restricted to asparagus as a food plant. Until the year 1906 it had not been recognized as doing injury to cutting beds, although attack had been observed in various sections. The mines of the larvæ about and below the bases of the stalks are frequently so abundant that they have the effect of girdling, so that the injured stalks can be readily pulled from the ground.

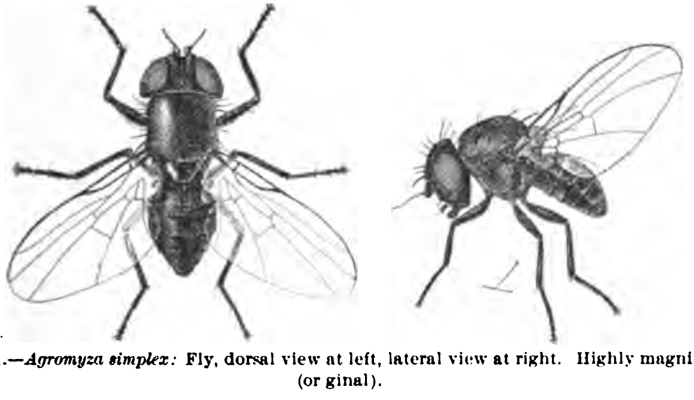

FIG. 1.—*Agromyza simplex:* Fly, dorsal view at left, lateral view at right. Highly magnified (original).

DESCRIPTIVE.

The parent insect is a two-winged fly (fig. 1), metallic black, with large prominent head and eyes, and clear wings, the wing expanse being about one-sixth of an inch (4 mm.).

The larva (fig. 2, *a*) is about one-fifth of an inch long and milk-white in color. Like other maggots, it is footless, large at the posterior extremity, and tapering toward the head.

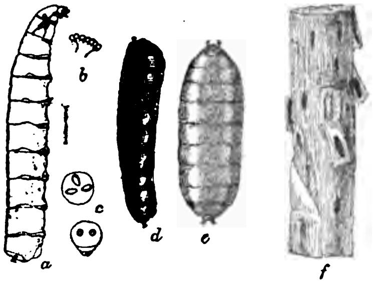

FIG. 2.—*Agromyza simplex: a*, larva, lateral view; *b*, thoracic spiracles; *c*, anal spiracles; *d*, puparium from side; *e*, same from above; *f*, section of asparagus stalk, showing injury and location of puparia on detached section; *a-e*, much enlarged; *f*, slightly reduced (original).

The puparium (fig. 2, *d*, *e*) is not unlike the "flaxseed" of the pernicious Hessian fly, with which it has been aptly compared. At a little distance, also, it suggests a Lecanium scale. This stage is remarkable because of its peculiar flattened and curved position, as seen from the side. It is red in color, and measures about 3.5 mm. in length and about 1 mm. in width.

The egg has not been observed.

This species belongs to the dipterous family Agromyzidæ, and was described by Loew in 1861,[a] the locality being given as "Middle States."

DISTRIBUTION.

In its injurious occurrences this species appears to be limited to the eastern United States, from New England to Tennessee. From available data it is quite obvious, however, that it may be destructive over a considerable territory, including a large portion of Massachusetts and Connecticut, Long Island, the District of Columbia, Pennsylvania, and Tennessee. As it is recorded from New Jersey, it is probably injurious there, although no reports of injury in that State have reached this office. In time it will doubtless attract attention in intermediate points and in States farther north and west. It has also appeared in asparagus beds in California.

HISTORICAL AND BIOLOGICAL NOTES.

In May, 1897, and afterwards this fly was observed in abundance by the writer on terminal shoots of asparagus, particularly at Cabin John, Md. Two weeks later no more flies were seen, but June 26 they reappeared and were then usually seen *in copula*. It was surmised at the time that this second appearance indicated the first new generation of the year and its abundance on asparagus seemed to show that it lived in some manner at the expense of that plant. Examination of asparagus plants at that time, however, failed to show attack. The facts which have just been narrated were published in 1898.[b]

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[a] Diptera Americæ septentrionalis indigena, Centuria octava 84, p. 160.

[b] Bul. 10, n. s., Div. Ent., U. S. Dept. Agric., p. 62, 1898.

In 1900 we received complaint of injuries in the District of Columbia, and from Knoxville, Tenn., and in the meantime the species came under the observation of Mr. F. A. Sirrine, who has stated[a] that work was first observed in asparagus fields on Long Island in 1896. This statement is made in a bulletin of six pages, which represents all that was known of the species at that time.

Late in September, 1900, word was received from Mr. Frederic Voigt, Tennallytown, D. C., of injury to the stalks of asparagus on his and a neighboring truck farm. When the writer visited the field, however, although injury was apparent on the outer skin of some stalks, no living specimens could be obtained, only the dried puparia being in evidence at this time. October 2 of the same year, Mr. Samuel M. Bain, University of Tennessee, Knoxville, Tenn., sent a stalk of asparagus showing the work of this miner upon the skin, and, October 27, specimens of the dried puparia.

February 18, 1901, Mr. T. Miles Brous, Bustleton, Philadelphia, Pa., wrote that this insect, which he accurately described, seemed to cause much greater trouble than the common asparagus beetle. A neighbor had lost two or three new beds of asparagus on account of its ravages.

By the writer's direction, Mr. F. C. Pratt visited a large truck farm at Brookland, D. C., where asparagus was one of the main crops, June 18, 1902. Asparagus was still being cut for market, but volunteer plants were growing here and there in fields of corn, cantaloupe, and potatoes, between rows. A few flies were seen on terminal shoots of asparagus that showed wilting, and many volunteer plants were found badly infested, most individuals having transformed to pupæ. Although stems break off just below the ground, the entire colony of insects below that point is left with sufficient moisture and nourishment for their maintenance. The puparia were present in great numbers underneath the outer skin of the root, and as many as nine puparia were counted in a space only an inch long on one stalk. The stalks below the point of injury appeared to be perfectly sound. Larvæ also were found in rotting stalks that broke off just below ground.

During 1905 Mr. Ralph E. Smith reported this species as becoming abundant in California, though not of any great importance at that time. His description of the insects' manner of work leaves no doubt as to the identity of the species.[b]

RECENT INJURY.

During September, 1906, Messrs. J. B. Norton and A. D. Shamel, of the Bureau of Plant Industry, furnished stems of asparagus from Concord, Mass., showing severe infestation by this species, many puparia being present under the mined outer skin. In the neighborhood of Concord, a very important asparagus-growing region where hundreds of acres are devoted to this crop, the infestation was practically absolute, the insect being found even as abundantly as the common asparagus beetle, being present wherever rust was found, as also where no rust was present. The specimens submitted were about the average as regards the degree of infestation, some plants showing injury 7 inches below the surface.

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[a] Bul. 189, N. Y. Agric. Exp. Sta., p. 277, Geneva, 1900.

[b] Bul. 165, Univ. of Cal. Agric. Exp. Sta., p. 96, 1905.

Severe injury was reported on the farms of Mr. Frank Wheeler and Mr. Charles W. Prescott, at Concord, Mass. The growers in that region had never noticed this insect until Mr. Shamel's examination showed that its injuries were extensive. Later Mr. Shamel reported finding infestation in every field and patch of asparagus which he visited in Massachusetts and Connecticut, particularly at Suffield, Granby, and Hartford, Conn., and he believed attack to be widespread.

October 26, 1906, Mr. Ralph E. Smith wrote, by request, that the conditions under which this asparagus miner was found in abundance in the yellow stalks of asparagus in California, as reported by him in an article on Asparagus Rust Control,[a] had prevailed for two or three years. The insect was always very abundant at the base of these yellow, dying stalks, although the injury was attributed to the "centipede," reported as wireworms on a previous occasion.[b]

REMEDIAL MEASURES.

With our present knowledge of the life economy of this species, two methods of control suggest themselves as of greatest value, and it may be that they will prove all that is necessary under ordinary conditions.

(1) In spring permit a few volunteer asparagus plants to grow as a trap crop, to lure the fly from the main crop or the cutting beds for the deposition of her eggs. After this has been accomplished the trap crop should be destroyed by pulling the infested plants and burning them with their contained puparia. The time to pull the plants will vary according to locality and somewhat according to season also. The second and third week in June would be about the right time in and near the District of Columbia. On Long Island this work should be done a week or two later. In the northernmost range of this insect—for example, in Massachusetts—the last of June and the first of July would probably be a suitable time.

(2) The second generation can be destroyed in like manner by pulling old infested asparagus stalks as soon as attack becomes manifest and promptly burning them also.

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[a] Bul. 172, Univ. Cal. Agric. Exp. Sta., p. 21; [b] Bul. 165, l. c.

If this work were carefully done over a considerable area, it would leave little necessity for other methods, since it would do away with these insects in the vicinity and leave few to be dealt with another season; unless, indeed, this insect has an alternate food plant. The cooperation of neighboring asparagus growers and thoroughness are essential for success.

This method will operate also against the rust which is now present in many fields infested by the miner.

NOTES ON THE ASPARAGUS BEETLES.

Since the publication of the writer's general article on the asparagus beetles in the Yearbook for 1896,[a] many notes on their distribution and destructive occurrences have been published. Some additional data were published soon afterward.[b] The following brief review of the subject is submitted as a sequel to those articles and a summary of the further dissemination of these pests in a decade of years.

THE COMMON ASPARAGUS BEETLE.

(*Crioceris asparagi* L.)

The predictions made by the writer in regard to the future distribution of the common asparagus beetle have been completely fulfilled as regards its western spread, although it has not as yet been reported as far south as Kentucky. Mr. J. G. Sanders, however, informs the writer that it has been established about Columbus, Ohio, since 1903, and Mr. Charles Dury, Cincinnati, Ohio, reported this species at Indian Hill, about 7 miles from that city, on asparagus beds in 1905. Hundreds were observed during June. The customary injury was noticed, and plants appeared as though scorched with fire. In 1897 the species was observed to have continued its spread westward along Lake Erie, and was then known in nine counties in northeastern Ohio. The following year it was first noticed in western Virginia. In 1898 also it was reported to have been present at Benton Harbor, Mich., since 1896. By 1899 it had made its appearance in Canada, accompanied by the twelve-spotted species, in the Niagara River region.

It is interesting to note that in 1900 the present species, which had been rapidly increasing its range in the East, including New York, after occurring in injurious numbers in Maryland, was apparently totally destroyed by the hot spell of July and August that occurred in the District of Columbia and neighboring parts of Virginia and Maryland; whence the conclusion that this condition prevailed to a considerably larger extent than came to the writer's personal notice. In 1901 Dr. James Fletcher noted that the species, though present in the Niagara district, had not increased to the extent that was feared. It had spread to Guelph, Ontario, that year, and did much damage about St. Catharines. In 1904 its occurrence around Toronto was noticed. It was reported also 40 miles west of Chicago, Ill. It has become very generally distributed in asparagus-growing districts in New York State, and has reached Glens Falls, which approximates its northernmost limit in this country. In 1905 we received complaint of this insect as a pest in Illinois, at Park Ridge, and of its occurrence about Chicago. Reports from Michigan showed that it had been present there in 1904 in the vicinity of Ada, about 10 miles from Grand Rapids, and that it was a pest in that vicinity.

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[a] Yearbook U. S. Dept. Agric. f. 1896 (1897), pp. 341–352.

[b] Bul. 10, n. s., Div. Ent., U. S. Dept. Agric., pp. 54–59, 1898.

Although the data given above indicate that the species is now well distributed throughout the Upper Austral region, for some reason its occurrence in Indiana has not yet come to our knowledge; nevertheless although there are naturally many uninvaded localities, it is undoubtedly established in that State, most probably near Lake Michigan.

As an example of its manner of distribution, it might be noted that in May, 1905, the beetle was found for the first time in Warrenton, Fauquier County, Va., a little farther inland than it had ever been noticed in that section. Yet this species has been permanently established in the adjoining Alexandria County for many years.

August 8, 1905, Mr. Ralph E. Smith wrote of the occurrence of this species in California, stating that during two seasons it had been very abundant at Bouldin Island, the principal asparagus center of that region. As Mr. Smith was familiar with this insect and its occurrence on the Atlantic coast, there is little doubt that his identification is correct. In the winter of 1904 to 1905 Bouldin Island was flooded and remained under water for over a year. It had just been reclaimed and there were no signs of the beetles. There is, therefore, a possibility that the insect was exterminated in that region, and this includes the State, if the occurrence of the species was only local.

The dying out of this asparagus beetle in small localities where it has not become thoroughly established is not without precedent, as its recorded occurrence at Rock Island, Ill., many years ago, has been verified by specimens now in a Chicago museum, properly labeled as collected there by the late A. Bolter, an experienced collector of Coleoptera. Indeed, it would seem that few vegetable-feeding insects are more subject to extermination in a limited locality not contiguous to one also infested than is the present species.

October 26, 1906, Mr. Ralph E. Smith, at the writer's request, reported the status of this species in California. He wrote that during the summer he found the beetles again, and that they were very abundant in fields near Oakley, Cal. It could not be stated that the insect was of general occurrence in the State, but apparently it existed only in a few scattered colonies. As previously reported the colony at Bouldin Island appears to have been exterminated by flood, and the Oakley occurrence was the first that Mr. Smith had noted since. In most of the asparagus acreage of the State the insect was not yet present.

Mr. Franklin Sherman, jr., has kept a careful record of the occurrence of this species in North Carolina, and informed the writer, on the occasion of a visit in 1906, that it is common in the east-central part of the State in the trucking belt, and especially abundant at Raleigh, Wake County, Goldsboro, Wayne County, and Warsaw, Duplin County.

In order to make the present account of the known distribution of this species as complete as possible, inquiry was made of the official entomologists of the States of Kentucky, Iowa, Missouri, Nebraska, and Minnesota, all of whom reported that the occurrence of this species in their States had not been brought to their attention. Mr. James G. Moore, however, assistant in horticulture at the University of Wisconsin, Madison, Wis., stated that the asparagus beetle had been found in Wisconsin, but he had no special data on its distribution.

REMEDIES.

With regard to remedies good results have followed the experimental use of arsenate of lead. This insecticide has come into very general favor in recent years, and in the correspondence of this office we have for some time advised its employment against most leaf-feeding beetles, like the asparagus beetles. In Connecticut Dr. W. E. Britton[a] has made a practical test of this remedy on asparagus plants, spraying them from all four sides in succession because of the slight leaf exposure as compared with most other plants. The day following treatment (June 4) many dead beetles and larvæ were found on and under the plants. A few had survived and were feeding, but ten days later only a few living larvæ could be found, and the beetles did not again become abundant on the plants during the summer. The same amount of good might be accomplished with scarcely greater expense by spraying from opposite sides and repeating just before the time for the last generation to develop and in time to check the beetles before they go into winter quarters.

In Pennsylvania Prof. H. A. Surface,[b] in a series of experiments with Paris green and arsenate of lead, applied to asparagus plants the first week of June, 1905, found that not more than 50 per cent of the insects were killed when Paris green and lime were used. With lead arsenate 90 per cent were killed, while in one experiment, by the addition of resin soap, which is used as an addition to an insecticide to enable the poison to adhere better to smooth plants, 100 per cent of the insects were killed on the 50 plants treated. In this case the arsenate of lead was used at the rate of about 1 pound to 24 gallons of water, and 2½ pounds of soap were added.

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[a] Rept. Conn. Agric. Exp. Sta. f. 1903 (1904), pp. 275, 276.

[b] Monthly Bulletin, Div. of Zool., Pa. State Dept. Agric., Vol. IV, May, 1906, p. 8.

Arsenate of lead has been used with satisfactory results on asparagus at the rate of 1 pound in 16 to 24 gallons of water. Additional experiments are necessary to ascertain the exact amount of the poison that can be used economically to produce the best effect. In Professor Surface's experiments evidently only a single spray was applied.

THE TWELVE-SPOTTED ASPARAGUS BEETLE.

(*Crioceris 12-punctata* L.)

Nearly every year since 1896, when the distribution of the twelve-spotted asparagus beetle was recorded by the writer,[a] the appearance of this species has been noted in new localities in the United States, until it is now well distributed westward and especially northward.

In 1898 Dr. J. B. Smith stated that it then occurred throughout the State of New Jersey "south of the shale from the Atlantic coast to the Delaware." The following year (1899) it was recorded by Dr. E. P. Felt from different counties in New York, and as far west as Buffalo. In some places the species was abundant, while in some near-by localities it could not be found, showing that it was still locally distributed through New York. It was afterwards recorded present in Albany, Batavia, Leroy, Syracuse, Riverhead, Oswego, Center, Glendale, Richmond Hill, Penfield, Elmira, Geneva, Ithaca, and about Brooklyn, N. Y. It was also stated to occur in the Niagara district in Canada as far back as Hamilton, Ontario.

An interesting point in regard to the occurrence of asparagus beetles in the Niagara peninsula was that the two species appeared to have arrived almost simultaneously in that region, but that the twelve-spotted form was by far the more common one. In after years different observers noted its further spread in Canada, commenting upon the fact that it led the common species in becoming diffused by natural means. By 1902 it had appeared in Connecticut, at New Haven, and later in other parts of that State.

Since some writers on these asparagus beetles have overlooked the author's second article[b] it may be well to mention that facts additional to those printed in the writer's original article are given therein, including a description and illustration of the egg and its manner of deposition, and what is practically a complete account of the life history of the species, the insect being found to develop and to feed where possible almost exclusively on the berry, although the beetles attack young asparagus shoots before the berries appear.

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[a] Yearbook U. S. Dept. Agric. f. 1896 (1897), pp. 350–351.

[b] Bul. 10, Div. Ent., U. S. Dept. Agric., pp. 57–59, 1898.

The young larva.—The freshly hatched larva has not hitherto been described. It may be briefly described as follows:

Head rounded, nearly twice as wide as long as seen from above; thoracic plates distinctly separated at the middle, with the intervening space yellow; legs infuscated, clear whitish at sutures. General color very pale yellowish, nearly white, and the surface much wrinkled. Length 1 mm., width 0.35 mm.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 66, Part II.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE WATER-CRESS SOWBUG.

THE WATER-CRESS LEAF-BEETLE.

BY

F. H. CHITTENDEN,

Entomologist in Charge of Breeding Experiments.

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U. S. D. A., B. E. Bul. 66, Part II. Issued April 23, 1907.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE WATER-CRESS SOWBUG.

(*Mancasellus brachyurus* Harger.)

During the past three years this isopod has attracted very considerable attention because of its occurrence in troublesome numbers in water cress (*Nasturtium officinale*) grown for market in portions of Virginia, West Virginia, and Pennsylvania. The species is purely aquatic, thus differing from our common dooryard sowbugs, which, although most abundant in moist locations, are strictly terrestrial. It belongs to an entirely different family, the Asellidæ, which contains three genera, mostly fresh-water forms, inhabitants of streams, wells, pools, and lakes.

DESCRIPTIVE.

This species is so distinct from the more common sowbugs (Oniscidæ) that a brief description will suffice. Its general appearance is shown, dorsal view, in figure 3. The body is much depressed, and the legs are long and strong. Seen from the side, it is decidedly shrimplike. The peculiar structure of the antennæ may be noticed in the illustration. They terminate in long flagella, composed of many joints. When mature this sowbug attains a length of 13 or 14 millimeters, or a little upward of half an inch, and is a little more than twice as long as wide, and gray in color. This creature is not an insect, but a crustacean, and therefore classed with crayfish and crabs. A detailed description is given by Miss Richardson,[a] who briefly mentions McKees Spring, Gaylord, and Lexington, Va., as localities where this sowbug was "reported injurious to water cress."

By recent correspondence we have obtained necessary information in regard to the habits and manner of operation of this sowbug, and we have also been successful in ascertaining what promises to be a very perfect remedy for the pest in its occurrence in streams and in spring water. It appears to affect cress only below the surface of the water, attacking the roots and lower leaves, and cutting off the stems near the bottom, causing bunches of the plant to float. In portions of streams where these sowbugs have been found most abundantly they are frequently seen crawling in a thick mass at the bottom. They feed, so far as known, exclusively on cress, not being reported as attacking any other form of vegetation.

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[a] Monograph of the Isopods of North America. By Harriet Richardson. Bul. 54, U. S. National Museum, Washington, 1905, pp. 411–412, figs. 460–461.

REPORTS OF INJURIOUS OCCURRENCES.

This sowbug has been observed as a pest since 1902. Our first report of its pernicious habits was made in 1904, when we received specimens through Mr. J. W. Bryan, Anacostia, D. C., from Halltown, W. Va., where it was very injurious to water cress.

In March, 1905, Mr. Powell Arnette reported injury at Gaylord, Va., to cress grown in spring water. The sowbugs were always found in the water and did not attack cress above the surface. After destroying the last vestige of cress in one of his ponds they remained on the bottom "a foot deep," crawling about on the mud.

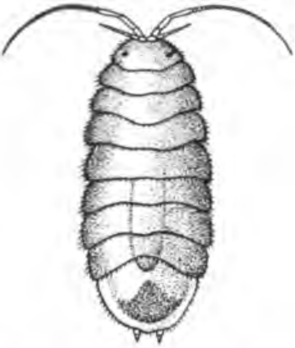

FIG. 3.—The water-cress sowbug (*Mancasellus brachyurus*). Enlarged (after Richardson).

During 1906 (June 18) Mr. John H. Reed, Carlisle, Pa., wrote in regard to this species and its destructive work on water cress in his locality. Specimens were received August 11. The sowbug was observed principally on the roots and lower leaves, crawling up along the stem and cutting off the leaves. August 10 Mr. George C. Jordan, Washington, D. C., sent specimens from Basic City, Va., stating that this "water bug" was devouring his cress beds, and, since a million or more were colonized on the plants, there would be no crop at the rate they were reproducing. When the plants were lifted the sowbugs were observed to drop from them.

METHODS OF CONTROL.

Three ways of controlling this species are suggested. The first and most important consists in a method of growing the water cress so as to eliminate injuries by the sowbug. The second falls under the head of direct remedies, and none of these has as yet given satisfactory results. The third consists in the use of fish or fowls as destroyers. This last means of eradicating the pest has not yet had a fair trial.

The following description of a successful method of disposing of the cress sowbug has been placed at our disposal by Messrs. B. Bryan

& Son, who are practical cress growers and have had several years' experience with the pest:

A METHOD OF GROWING WATER CRESS TO DISPOSE OF THE SOWBUG.

The damage done by the sowbug to water cress has made it our greatest enemy in cress growing, and only after fighting it for four years have we succeeded in finding a way to keep down its numbers so as to be sure of a crop. As cress is ordinarily grown—in lakes or streams of spring water anywhere from 6 inches to 3 feet in depth—it seems impracticable to apply any insecticide. At first we tried to catch the bugs with wire-netting traps placed where the whole stream of water had to pass through them, but the bugs remained among the cress, and we caught only about 20 per cent.

Later, in using copper sulphate to kill moss in the cress, we found that it also killed the sowbugs, snails, etc., when applied freely. Further experiments, however, proved that bluestone could not be applied in deep running water any better than the insecticides previously tried, and when applied in shallow or still water it injured the cress.

The method we are employing at present to fight the sowbug is largely a matter of arrangement of cress beds (see fig. 4), and can be used only where the bottoms of the beds can be graded and drained or where level land adjoins the source of the water supply. We dug long trenches in level land, making them 16 feet wide and about 15 inches deep. Lengthwise they were graded to give a fall of 3 inches in 100 feet, and crosswise to make the center of the trench several inches deeper than the sides. In the center and running the full length of the trench a trough made of three 10-inch boards was sunk below the bottom of the trench in such a way that all of the water might be drained out of the trench through it. Then, with the upper and lower ends of the trench and trough arranged to be opened or closed, the trench could be filled or emptied at will and the flow of water regulated up to 8 inches in depth over the cress. Of course fertile soil was put in the trenches and the cress could be planted either before or after the water was turned in.

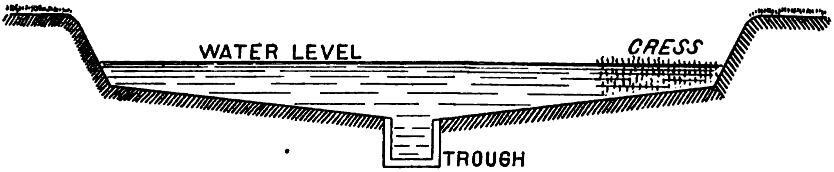

FIG. 4.—Cross section of cress pond showing arrangement for avoiding damage by the water-cress sowbug.

With cress beds arranged as above, manipulation to dispose of the sowbugs is simple. By cutting off the water supply and allowing the water to pass out at the lower end of the trench, the sowbugs will collect in the trough, following the receding water, as they can live only in water. No little puddles should remain among the cress, as the bugs will collect in them instead of in the trough. It will be found necessary, also, to use boards to walk on in gathering the cress, as prints of one's boots in the beds would make holes for the bugs to shelter in. The bugs do not move until nearly all of the water is drawn out of the trench. Thus they are collected in a small amount of water in the trough and can then be readily killed with a liberal amount of bluestone, either solid or in solution.

To make the work thorough, water should not be turned into the trench again for twelve or twenty-four hours, in which time the few bugs left among the cress stems will die or find their way to the trough. The trenches can be cleared of bugs in warm weather as frequently as desired, but less danger is done the cress crop if the work is done just after gathering the cress.

The same method of disposing of the sowbugs could be used in greenhouses in the winter, but cress grown in the open air could not be exposed in freezing weather, making the remedy inapplicable in cold weather.

We have not used water in these trenches deeper than 10 inches, and are not able to say how a larger or more rapidly flowing supply of water would act. nor have we grown winter cress in them, as our water supply is insufficient for that purpose.

OTHER REMEDIES.

About the only other remedies which we have been able to suggest are the use of a substance, such as sulphate of copper or chlorid of lime, which might be placed in the water to destroy the pest. As the former has already been tested by Messrs. B. Bryan & Son (see page 13), it need not be mentioned further.

Mr. John H. Reed states that a grower at Healing Springs, Va., has a remedy consisting of a poisonous material which is placed in the water, but he does not know the ingredients nor whether there would be danger to stock drinking the water below the spring. He writes also of the possible use of chlorid of lime. A tank of bleach composed principally of chlorid of lime ran into a creek at Mount Holly Springs, Pa., killed everything that was living in that stream for about half a mile downward, but did not poison stock that drank the water. The bleach came from a paper-mill tank which had burst. If chlorid of lime is tested it should be used on a very small scale at first to note the effect on plant life. It is apt to be harmful to trout and other fish present.

Mr. Reed also suggested the employment of ducks to destroy the pest, but this would necessitate the abandonment of cress culture for a season, as the ducks would injure the condiment both by eating it and by fouling the water.

Among other remedies, we have recommended draining off the water where possible and exposing the sowbugs to the drying effects of the sun.

FISHES AS A POSSIBLE MEANS OF DESTROYING THIS ISOPOD.

In response to inquiry, the following information was received from the Bureau of Fisheries, through Mr. Lawrence O. Murray, Acting Secretary, Department of Commerce and Labor, in regard to the fishes which might be found useful in the destruction of this aquatic isopod in its occurrence on water cress:

Among the fishes which would probably prove most useful for this purpose and with which it is suggested that the Department may wish to experiment are the fresh-water killifishes *Fundulus notatus*, *F. diaphanus*, and *F. dispar*. The first occurs from Michigan to Alabama, Mississippi, and Texas, and is rather common in small lowland ponds. The second is found from Maine to North Carolina in river mouths, in the Great Lakes, and in practically all of the small lakes in the upper Mississippi Valley. The third occurs in smaller lakes and ponds from northern Ohio to Illinois and south to Mississippi. Specimens of each of these species could be obtained at any one of several small lakes in the northern part of Indiana.

It is probable that some of the catfishes might also be useful in this connection, and it is suggested that it might be worth while to try one or more of the small species known as "mad Toms," belonging to the genus *Schilbeodes*. One or more species of this genus can be found in almost any small, sluggish stream in Pennsylvania, Virginia, and West Virginia.

The writer believes that carp should prove of value in keeping down this cress sowbug, there being one drawback, however, that the carp must be watched to see that they do not develop too rapidly and that they do not attack the cress or make the water muddy. Catfish have been tried and found wanting in the case of the water-cress leaf-beetle, which will be considered elsewhere (pp. 16–20).

THE WATER-CRESS LEAF-BEETLE.

(*Phædon æruginosa* Suffr.)

INJURIOUS OCCURRENCE.

Among plant-feeding native insects which have recently appeared in new rôles is a little blackish leaf-beetle, *Phædon æruginosa* Suffr., which was reported for the first time as injurious to water cress (*Nasturtium officinale*) in Pennsylvania, in 1903.

During September Mrs. Hannah B. Hannum, Brandywine Summit, Pa., sent larvæ and adults of this species, with statement that they were devastating her water-cress pond. Both larvæ and beetles fed chiefly on the lower side of the leaves. In confinement they continued feeding, attacking the stalks also. The larvæ all reached development about the same time, being fully matured September 11 and 12, on the last of these two days crawling about the rearing jar and ceasing to feed. The pupal period was not observed, but it probably lasted ten days or a fortnight, as the weather was cool. The beetles continued for some time in our rearing cages, frequently pairing, but depositing no eggs.

August 19, 1904, Mrs. Hannum sent additional specimens of this species in the beetle and nearly grown larval stages. It was noticed that the beetles did not swim rapidly, but steadily, and they were seemingly not discomposed by being somewhat out of their natural element. It seems probable that they fly from plant to plant, and like most beetles undoubtedly are able to float for many hours, and perhaps even swim short distances until they reach a landing place. September 13 our correspondent sent still another lot of this species, mostly beetles, but a number of larvæ were included.

Specimens of the larvæ of a syrphus fly accompanied this sending and probably fed at times on the small larvæ of the beetle.

DESCRIPTIVE.

The beetle.—This species belongs to the tribe Chrysomelini of the family Chrysomelidæ. It is classified in our publications on the Coleoptera of America north of Mexico with Plagiodera, but European systematists place allied forms in the genus Phædon Latr., which now comprises seven species occurring in our country. They are very small semiglobose forms. The outline is oval, with the thorax narrowed anteriorly and the apex margined. The elytra have eight punctate striæ, with a short subsutural and submarginal row of punctures. The third joint of the tarsi is emarginate apically.

The present species measures a scant one-eighth of an inch in length (3 mm.), is shining bronzy black, and has the elytral intervals apparently smooth, but in reality faintly rugulose when highly magnified, while the thorax is microscopically reticulate. The original description appeared in 1858.[a]

The egg.—The eggs have not come under observation. They probably resemble those of the European *Ph. armoraciæ* L., described by Fryer as " elongated oval and of a dark orange color."

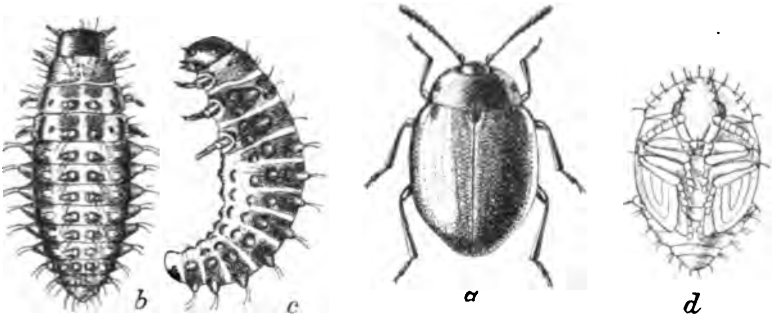

FIG. 5.—The water-cress leaf-beetle (*Phædon æruginosa*): *a*, adult; *b*, larva, from above; *c*, same, from side; *d*, pupa. Enlarged twelve times (original).

The larva.—The larva appears somewhat like that of a related genus, Galerucella, only that it is very much smaller. It is about three or four times as long as wide, depending upon whether it is somewhat contracted or fully extended. The head is subtruncate in front, with the antennæ lateral (in preserved specimens). The head is shining black, and the remainder of the body very dark brown or brownish black relieved by lighter areas between the segments. The first thoracic segment is a little wider than the head; the second considerably wider than that, and the third widest, being nearly as wide as the first two abdominal segments. The second abdominal is widest, and at the same time the widest part of the body. The surface is sparsely covered with long hairs placed on piliferous tubercles, which are arranged some distance apart, as shown in figure 5, *b*. The tubercles on the sides of the dorsum are sometimes very prominent, and the larva is able to extend these, possibly, at will. From the abdominal segments large tubercular sections bearing hairs at their summit extend on each side. The anal segment is pale, like the ventral surface, which bears dark piliferous tubercles. Length, 5 mm.; width, 1.2–1.5 mm.

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[a] Ent. Zeitung, Stettin, Vol. xix, pp. 395, 396, 1858.

The pupa.—The pupa is illustrated by figure 5, *d*, which will answer better than a verbal description. The color is yellow, and the length is slightly less than that of the adult.

The distribution of this species is probably moderately wide and additional study must be given this subject. At present we know of its occurrence in the District of Columbia, in Massachusetts, and probably in West Virginia.

LITERATURE.

Brief mention of the occurrence of this leaf-beetle as an enemy of water cress in Pennsylvania in 1893 was made by the writer,[a] but Mr. Frederick Knab, of this office, mentioning the same species as *Plagiodera viridis*, has recorded [b] its occurrence in great abundance upon water cress near Springfield, Mass., in 1902. The identity of the species in question has been verified by the comparison of specimens, and Mr. Knab's record was evidently made on the assumption of Crotch [c] that *æruginosa* was merely a variety of *viridis*.

HABITS OF THIS AND A RELATED SPECIES.

We can not at the present writing give an approximate statement of the life history of *Phædon æruginosa*, and hence must depend on what is known of the related *Ph. armoraciæ*, which is common to both continents.[d] This letter has evidently been introduced into this country, but its habits have apparently not been studied here. It is known in England as the blue beetle and mustard beetle,[e] and is of considerable importance locally, in some seasons ravaging entire fields of mustard, cress, cabbage, and kohlrabi. It passes the winter as adult, reappearing in spring on cruciferous plants. Fryer stated that in the three years prior to 1881 the Isle of Ely, England, suffered from the ravages of this species, entire fields being injured. Mustard was attacked at about the time of the formation of the seed pod and after the stalks were stripped nearly to the cuticle the beetles transferred their attention to kohlrabi, which they completely consumed, at first attacking the leaves and afterwards the bulbs, leaving nothing but bare stalks.

The water-cress leaf-beetle is doubtless no exception to the general rule among most Chrysomelidæ and other species of Phædon, in laying its eggs on the under side of the leaves. Both larvæ and adults attack the cuticle of the stem after feeding on the leaves, as has been noticed in the case of *armoraciæ*. E. A. Fitch has observed the partiality of the latter for water cress and other crucifers which grow in watery places and mentions the destruction of an entire crop of horseradish.

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[a] Ybk. U. S. Dept. Agric. f. 1903 (1904), p. 564; [b] Entomological News, March, 1903, p. 89; [c] Crotch, Proc. Acad. Phila., 1873, pp. 54, 55; [d] *Phædon armoraciæ* L. syn.: *Plagiodera cochleariæ* Panz., Gyll.; *Phædon betulæ* Küst. It is not the same as *cochleariæ* Fab. [e] Fryer and others have given accounts of this species in The Entomologist (Vol. XIV, pp. 44, 187, etc.).

Kaltenbach[a] records, according to Gyllenhall and his own observations, *Veronica beccabunga*, *Cardamine amara*, and *Cochlearia armoracia* or horseradish as food plants, and states that the larva undergoes metamorphosis in the earth, the pupa state lasting fourteen days. Cornelius[b] is cited as having observed two generations, the spring generation being found in May and June and the second in September. Thomas H. Hart records the water starwort of England (*Callitricha verna*) as another host plant. T. R. Billups,[c] an entomologist as well as truck grower, mentioning this species as *Phædon betulæ*, states that it is "one of the greatest insect pests the market gardeners around London have to contend with." Our American species undoubtedly hibernate as adults and appear in early spring under boards and similar shelter.

METHODS OF CONTROL.

How to successfully control this insect under ordinary conditions is quite a problem. Paris green was tried by our correspondent, mixed with flour and sprinkled over the plants when the dew was on, and this reduced the numbers of the insect somewhat. Owing to the moist condition of the plants, however, the flour formed a paste which stuck like glue, and it was therefore abandoned. Applied in water it rolled off the plants. We were not informed if this application was made with a spraying machine. If the plants were sprayed lightly with a fine spray, it might answer, or, better, Paris green dry with only 20 parts of flour, or plaster or air-slaked lime. An arsenical should not be used within about a week of the time of cutting the cress for market. In the case of Paris green there is practically no danger of poisoning even if it were used later, as the washing which is given the cress will carry away all perceptible traces of the poison.

If conditions should be such that the pond or stream in which water cress infested by this species is growing could be completely overflowed, it would cause the insects to rise to the surface, and in the case of running water would wash them downstream. Flooding alone might not entirely solve the problem, as these beetles are able to survive considerable immersion.

When the cress is grown in sufficiently large bodies of water experiments should be made with some of the fish mentioned on page 15 as possibly useful for destroying cress insects. Ducks might also be found valuable. Catfish were tried, but without avail.

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[a] Pflanzenfeinde, p. 26; [b] Stett. Ent. Zeit., 1863, p. 123; [c] The Entomologist, Vol. XIV, 1881, p. 236.

Mrs. Hannum has recently written that she attained the greatest success by growing the water cress in running water which carried the beetles away. In cold weather it was necessary to plant in houses where the cress did well until the coming of warm and dry weather, when the beetles would sometimes clean it out almost entirely, leaving only the roots. By tearing the cress out of the houses and in ponds which were not exposed to running water she could replant her beds, and hoped in time to get rid of the pest.

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Sept. 17, 1907.
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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 66, Part III.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE CRANBERRY SPANWORM.

THE STRIPED GARDEN CATERPILLAR.

BY

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U. S. D. A., B. E. Bul. 66, Part III. Issued August 31, 1907.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE CRANBERRY SPANWORM.

(*Cleora pampinaria* Guen.)

A brownish spanworm has been observed by the writer during recent years on asparagus in the District of Columbia in such numbers as to indicate that it is especially attached to this crop, at least in this region. In consideration of the fact that so few insects attack asparagus, the accompanying account has been prepared. The species appears to have attracted no attention since 1884,[7] [a] when it was considered in relation to its appearance in cranberry bogs. From material recently collected, several facts hitherto unrecorded have been gained, and there are a number of unpublished notes of the Bureau showing a tendency on the part of the species to become omnivorous. At any rate it is not confined to cranberry, as the name given above would imply, nor to strawberry, as might be inferred from another name, "brown strawberry spanworm," which has also been given it. The list of food plants which will presently be furnished shows a considerable range. Owing to the fact that the insect has not often been observed concentrated on any single crop, little mention of it has been made in literature by economic writers. Cranberry is a favorite food plant, and is sometimes injured to a considerable extent, especially in Massachusetts.

DESCRIPTIVE.

This insect belongs to the lepidopterous family Geometridæ, the larvæ of which are well known under the common names of spanworms, measuring-worms, inch-worms, and loopers.

The moth which produces this spanworm is quite variable in color and markings. The average expanse of wing is from a little less than an inch to upward of an inch and a fourth (22–32^{mm}), but may exceed this, attaining, according to Dr. A. S. Packard,[4] a measurement of an inch and a half. The ground color of living specimens is pale

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[a] The numbers in superior type refer to corresponding numbers in the appended bibliography, p. 27.

leaden gray, and of old mounted material a duller gray, thickly diffused with black and brown dots and other markings more or less constant, forming irregular lines across both fore-wings and hind-wings. On both there is a marginal regular scalloped black line and within this a strongly dentate or zigzag white line. The general pattern of the wings varies considerably from that shown in figure 6, *a*, which represents the female. The color of the body is similar to that of the wings. The first abdominal segment is white above.

The sexes can be readily distinguished by the antennæ. Those of the female are filiform and tessellated and those of the male rather strongly pectinate, or feathered. The structure of the latter is shown at *e* and *f*, figure 6.

"It may be known," says Packard, "by the very distinct line at the base of the abdomen, the basal wing beyond being usually white, and the underside of the wings having a broad marginal shade, while the third line on the fore-wing is deeply but quite regularly sinuate and near the costa acutely dentate."

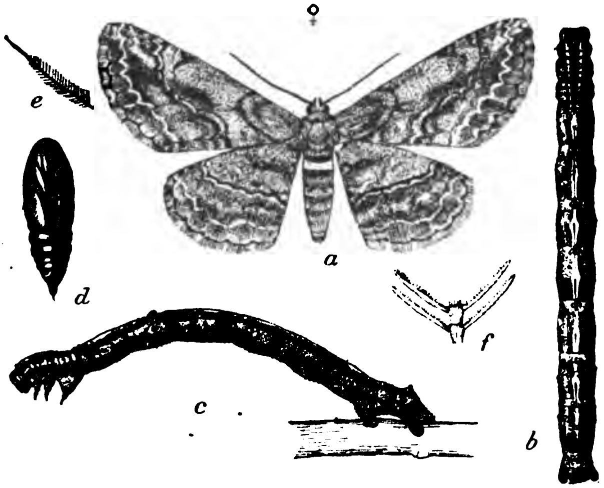

FIG. 6.—The cranberry spanworm (*Cleora pampinaria*): *a*, Female moth; *b*, larva, dorsal view; *c*, larva, lateral view; *d*, pupa; *e*, male antenna; *f*, enlarged joints of same. All enlarged; *e, f*, more enlarged (original).

A number of synonyms are credited to *Cleora pampinaria*. It has indeed received five specific names. As three of these were given by Guenée, it is of itself indicative of the variation of the moth. The list follows:

Boarmia sublunaria Gn., Spec. & Gen., IX, 248 (1857); *B. frugallaria* Gn., Spec. & Gen., IX, 246 (1857); *B. collecta* Wlk., Cat. Brit. Mus., XXI, p. 397 (1860); *Cleora tinctaria* Wlk., Cat. Brit. Mus., XXI, p. 486 (1860); *Boarmia fraudulentaria* Zeller. Verh. zool.-bot. Ges. Wien, XXII, p. 492 (1872); *Cymatophora pampinaria* Pack., Mon. Geom., p. 432 (1876).

The egg appears not to have been described.

The larva.—The larva resembles those of other geometrids in being of elongate form, about nine times as long as wide, with the three pairs of thoracic or front legs bunched closely together near the head, and in having only two pairs of prolegs, or unjointed legs, at the opposite extremity. The color varies to a considerable extent from mottled pale yellowish to brown, often with an olivaceous or greenish tint. Those which have been recently captured in the District of Columbia are reddish brown, mottled, streaked, and lined with lighter yellowish, red, and black. The head is strongly marked with transverse irregular black bands. The thoracic segments are marked above by a pair of thin median longitudinal lines. The second abdominal segment bears on the dorsal surface a pair of prominent, widely separated, mostly black tubercles, but in some individuals these are wanting. The penultimate segment also bears above a smaller pair of black tubercles. The larva when full grown measures an inch to upward of an inch and a fourth in length (25–33^{mm}) and the greatest diameter is about one-eighth of an inch (3^{mm}). The singular construction of the legs, or rather the lack of the intermediate legs usually present in caterpillars of other families, is the cause of the peculiar motions of the spanworms in crawling about in search of food, which have given them their popular names. When in motion a larva extends its body to full length, then brings the posterior legs close to the anterior ones, causing the body to loop in the center. The body is then stretched out again, these actions being repeated alternately.

When this spanworm is in repose it attaches itself to the foliage—for example, to the stem of asparagus—by means of its anal pair of legs and stretches out its body rigidly and at an angle so that its natural colors harmonize with the foliage or with the landscape. On this head Doctor Smith has remarked that on a section of cranberry bog on which this species is feeding the observer may stand in the midst of thousands of them and see none until something starts them into motion. Then it appears almost as though the entire bog were alive. As the spawnworms hang somewhat tenaciously to their food plants, they are undoubtedly present frequently in numbers without anyone being the wiser.

The half-grown larva is described by Doctor Forbes.[8]

The pupa, shown, ventral view, in figure 6 at *d*, is of robust form, light greenish brown in color, and a little less than half an inch in length (12^{mm}) and about a third of that (4^{mm}) in width.

DISTRIBUTION.

The wide distribution of this insect is shown by the following list of localities, based upon Doctor Packard's list, where the authorities for each locality are given: Maine; Amherst, Cape Cod, Cotuit, Natick, Mass.; West Farms, Center, Albany, and Brewster, N. Y.; Philadelphia, Pa.; Lansing, Mich.; Dayton, Ohio (Pilate); Glencoe, Nebr.; Cadet, Mo.; Centralia and elsewhere in Illinois; Washington and Brookland, D. C.; Georgia; Calhoun, Dawson, and Demopolis, Ala.; Lake Bearsford, Florida; Bastrop County and elsewhere in Texas.

The above localities indicate a distribution ranging from the transition life zone through the upper to the lower austral. The occurrence of the species in Florida, Alabama, and Texas would indicate that it is to be found throughout the Gulf region. The insects observed by Glover were stated to appear in the Carolinas, Georgia, and Florida in early October.

BIOLOGIC LITERATURE.

The spanworm under consideration was described under the name of *Boarmia pampinaria* by Guenée in 1857.[2] In 1876 Dr. A. S. Packard gave a detailed description of the moth, with a consideration of its distribution and remarks on the larva and pupa, the former being stated to feed on pear.[10] In 1881 Dr. G. H. French[6] had a note on the larva observed feeding on willow and geranium; larvæ transformed to pupæ September 16 and October 2, and the imagoes issued April 17 of the following year. During the year 1883 this species was observed by Dr. J. B. Smith,[7] then a temporary agent of this office, doing injury at Cotuit, Mass. During that year the spanworms were so abundant in the cranberry bogs in that vicinity that their numbers could be compared only to the army worm (*Heliophila unipuncta* Haw.). In the case in question they began in a space about a rod square, devoured that, and spread in a direct line across the bog. The number of moths that would have been produced from these insects should they have been permitted to transform was described as being "frightful." A rather full account by Dr. S. A. Forbes followed in 1884,[8] in which the statement was made that the larva was found in midsummer feeding on leaves of strawberry in southern Illinois. Larvæ obtained August 1 pupated on the 11th, and the moths emerged on the 22d, giving eleven days as the pupal stage at that season. Larvæ collected September 6, about half grown, were believed to represent a second generation. The larva of this species came under the observation of the writer on asparagus first in 1897.[11] In 1899 Doctor Lugger[12] stated that the caterpillars were found on apple and blackberry, and that there were at least two generations annually.

As this is one of the commonest species of its genus, of wide distribution, and authentically determined as living on cotton, there seems little doubt that it was the type of Glover's account of "the larger spanworm," figured and described in his accounts of insects frequenting the cotton plant, published in 1856[1] and again in 1878.[5] A curious blunder was made by M. D. Landon, who figured this species as the "cotton caterpillar (*Noctua xylina*)" in 1865,[3] this illustration being a crude copy taken from Glover's first or 1856 account of this spanworm.

UNPUBLISHED OFFICE NOTES.

June 5, 1879, we received from Mr. William Trelease, then at Dawson, Ala., larvæ found feeding on cotton. June 12 a larva kept under observation changed to pupa, and on June 26 the moth issued, this individual having passed 14 days as pupa. The same year the moth was reared on several occasions from material obtained on red clover in the District of Columbia by Messrs. Pergande and Howard. June 28 the moth issued from the pupa. August 15 the larva was observed feeding; changed to pupa August 25, and issued as moth March 1 of the following year. August 29 the larva was observed feeding; changed to pupa September 4, the moth issuing March 22 of the next year.

February 6, 1880, we received from Lake Bearsford, Fla., from Prof. J. H. Comstock, a larva obtained on orange.

There are also reared specimens of moths in the U. S. National Museum bearing labels showing the rearing of moths and occurrence of larvæ on different plants, as follows: On locust, May 6, 1893, District of Columbia; hickory, November 24, 1894, Cadet, Mo., and August 4 of the same year on pear, locality presumably the District of Columbia. There is also a specimen labeled "on guava," probably from Florida.

August 6, 1904, specimens of this spanworm were received from Calhoun, Ala., where they were found feeding on cotton and were mistaken for the cotton leaf-worm (*Alabama argillacea* Hbn.). The adult issued August 29. Larvæ were about full-grown when received, August 9, and it seems probable that they underwent a short stage of æstivation before transforming to pupæ, as the pupal stage is less than 20 days in midsummer.

During the first two weeks of October for several years larvæ have been observed on asparagus grown in the District of Columbia, the species appearing in moderate numbers. The first moth that has been reared from October-collected larvæ appeared in January, and others appeared in February. As this was in confinement the dates were not natural ones.

LIST OF FOOD PLANTS.

It is, as previously remarked, owing to the omnivorous habit of this species, causing a distribution of attack, that noticeable injury has not been ascribed to it elsewhere than in cranberry bogs. It is common enough in the vegetable and truck garden, but not confined to any particular place on the farm, occurring in orchards, on forest and shade trees, and on other plants. The list of observed food plants includes asparagus, strawberry, blackberry, ornamental geranium, apple, pear, orange, willow, hickory, cranberry, honey locust, cotton, clover, and guava. As a rule the larvæ confine themselves to the foliage of these plants, but Glover states that they sometimes feed upon the petals of the flowers of cotton, although doing little harm to the general crop.

THE INSECT'S LIFE HISTORY.

Our knowledge of the life history of this species is somewhat incomplete. The repeated rearing of moths in early spring and the occurrence of larvæ in the latter part of June in Massachusetts as recorded by Smith, as also in the District of Columbia and elsewhere as late as October, noted by the writer and others, show at least two generations in the Northern States, while the record of the occurrence of the moths in March in Texas (by Belfrage) would indicate that in the Gulf States there may be an additional generation. It would seem practically impossible for larvæ hatching from eggs deposited in early spring to require until late October to attain maturity, hence the natural inference of two generations for a climate like the District of Columbia. The cranberry growers of Massachusetts claim two generations for that State, one appearing as larvæ in June and early July, the other in the latter part of August.

The eggs are unknown, and the periods of egg and larva have not been ascertained, but the pupal condition has been observed to be passed, for the first generation, in from 11 to 14 days, while the over-wintering pupa consumes five or six months in the District of Columbia, a shorter time farther south, and a longer time northward.

The date of the appearance in the North of the first moths has not been learned positively nor the natural time of emergence of the first new generation of moths.

NATURAL ENEMIES.

Doctor Smith[7] has stated that the larvæ of this spanworm are checked by parasites, but that in some localities almost every year they become numerous enough to be destructive. In some years, however, in the cranberry bogs of New Jersey they are not seen at all, showing great scarcity, due probably in part, at least, to natural causes. Only one parasite for this species is known, namely, *Exorista boarmiæ* Coq., a tachina fly reared at this Department from Cotuit and other localities in Massachusetts several years ago.

REMEDIES.

This species is not difficult to control on asparagus or other truck crops. As it feeds in free exposure on the foliage, spraying with Paris green or arsenate of lead will destroy it, and when either of these insecticides is used for the asparagus beetles it will kill all of the spanworms which may be present. The Paris green may be used at the rate of 1 pound to about 100 to 150 gallons of water, and the arsenate of lead at the rate of about 1 pound to 25 to 50 gallons of water. The same remedies will apply equally well to the occurrence of this species in cranberry bogs.

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1. **Glover, Townend.** Report Commissioner Patents, p. 92, Plate VIII, fig. 4, 1855 (1856).

Probably this species. Appears in Carolinas, Georgia, and Florida early in October and feeds upon the petals of the cotton flower; larva and adult described and figured.

2. **Guenée, M. A.** Species Général des Lépidoptères, Vol. IX, Phalénites, pp. 245, 246, 248, 1857.

Original description as *Boarmia pampinaria* from near Baltimore, as *B. frugallaria* from Georgia, and as *B. sublunaria* from North America.

3. **Landon, M. D.** Rept. Comm. Agr. f. 1864 (1865), p. 90.

Erroneously figured as the "cotton caterpillar (*Noctua xylina*)."

4. **Packard, A. S.** Report U. S. Geological Survey Terr., Hayden, Vol. X, pp. 432, 442, Plate XI, fig. 20, 1876.

Technical and detailed description of moth; synonymy; distribution and note on larva and pupa, the former feeding on pear.

5. **Glover, Townend.** Cotton and its principal injurious insects<Washington, D. C., Plate VII, figs. 6, 7, 8, 1878.

Figures larva, chrysalis, and moth; found early in October in Georgia feeding on flowers of the cotton plant.

6. **French, G. H.** Papilio, Vol. I, p. 82, 1881.

Notes on larva found feeding on willow and geranium.

7. **Smith, J. B.** Bul. 4 (o. s.), Div. Ent., U. S. Dept. Agr., pp. 26–28, 1884.

A two-page account in reference to injuries to cranberries; description of larva; referred to as *Cymatophora pampinaria;* remedies.

8. **Forbes, S. A.** Thirteenth Rept. State Entomologist Illinois, pp. 76–78, 1883 (1884).

A rather full account. Larva found frequently in midsummer in southern Illinois feeding on leaves of strawberry; description of larva, pupa, and imago (quoted from Packard).

9. **Forbes, S. A.** Trans. Miss. Valley Hort. Soc., Vol. II, p. 235, 1884.

Quotations of first two paragraphs of No. 8.

10. **Packard, A. S.** Fifth Report U. S. Ent. Commission, p. 654, 1890.

Included in a list of insects affecting honey locust (*Gleditschia triacanthos*).

11. **Chittenden, F. H.** Bul. 10, n. s., Div. Ent., U. S. Dept. Agr., p. 61, 1898.

An unknown geometrid larva feeding on asparagus; subsequently ascertained to be this species.

12. **Lugger, Otto.** Fourth Rept. Entomologist State Exp. Station Minn., pp. 187, 188, fig. 188, 1898 (1899).

Notes on the moth; caterpillar found on the apple and blackberry. Short general account.

13. **Smith, J. B.** Farmers' Bulletin 178, U. S. Dept. Agriculture, pp. 19–21, 1903.

Account of injuries to cranberry, life history, and remedial measures.

THE STRIPED GARDEN CATERPILLAR.

(*Mamestra legitima* Grote.)

A strikingly beautiful black and yellow striped caterpillar is frequently found in gardens, and occasionally in such numbers as to attract attention. It is a general feeder, like most of its kind, but is somewhat partial to asparagus, cruciferous plants, peas, and other leguminous vegetables. Its occurrence in the District of Columbia in some numbers, especially on asparagus, has permitted a study of the species, which adds somewhat to what has previously been published. Only a few short notices of this insect have appeared in publications of the Department of Agriculture or elsewhere, to the writer's knowledge. The following somewhat brief account is therefore presented.

This species is a noctuid, related to the cutworms, and is congeneric with the zebra caterpillar (*Mamestra picta* Harr.). The moth was originally described in 1864,[a] the species at that time being known from the middle and eastern States, where it was stated to be common. It is also recorded as occurring in the northern States. Evidently, considering its numbers in the Gulf region, it may be found in most States east of the Mississippi River Valley.

DESCRIPTIVE.

The moth is quite prettily marked, as can be seen by referring to figure 7, *a*. The prevailing tint of the fore-wings is a light lead color, marked with velvety-black and brown spots, the pattern varying somewhat but usually about as figured. The lower wings are fawn colored, with dusky margins, and the veins are moderately prominent. The females, as is usual with this group, have the abdomen as illustrated, while the males have abdomens with bushy tips. The wing expanse is a little more than an inch and a quarter.

The eggs.—No description of the egg is available at the present writing.

The larva is also a pretty form and its markings recall the zebra caterpillar. It will be noticed by the figure (fig. 7, *b*, *c*) that there is considerable difference, however, and the two species are not at all likely to be confused by anyone who carefully examines them. The present species has a larger and wider head and is darker than is usual with the common zebra caterpillar. The appearance of the head from in front is shown at *d*. The stripes with which the body is ornamented are black and yellow, as with the zebra caterpillar, but the lateral stripe is divided into two portions, the upper one lighter than the lower, and the entire lateral surface when marked consists of regular stripes, whereas in the other species these stripes are broken up.

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[a] *Apamea legitima*, Proc. Ent. Soc. Phila., Vol. III, p. 82.

The pupa, when mature, is nearly black in color, and has the appearance illustrated (fig. 7, *e*). It measures about five-eighths of an inch in length, including the tips.

BIOLOGIC NOTES.

This species was briefly mentioned as having been found by the writer in the larval condition on asparagus at Marshall Hall, Md., in October, 1896.[a] At that time it was impossible to ascertain whether or not it bred from eggs deposited on this plant, but later observations conducted in company with Mr. F. C. Pratt during the first and second weeks of October show conclusively that such must be the case, as larvæ were found in the greatest abundance on three large patches of asparagus at Brookland, D. C. They usually occurred singly, but occasionally in pairs.

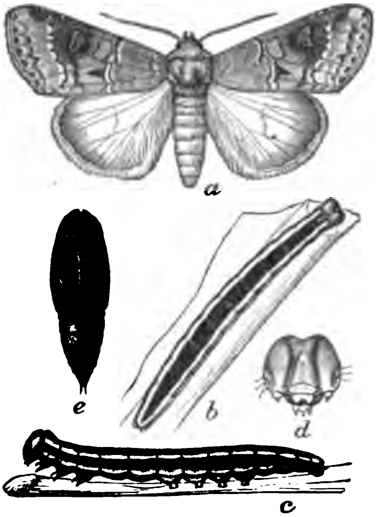

FIG. 7.—The striped garden caterpillar (*Mamestra legitima*): *a*, Adult; *b*, larva from above; *c*, same from side; *d*, head of same from front; *e*, pupa. All natural size except *d*, which is enlarged (from Howard).

During the heat of the day, in the moderately cool and seasonable Indian summer weather usual at Washington at that time of the year, many larvæ would be found stretched out upon dry sprigs of asparagus, and in spite of their bright colors they would easily have escaped the observation of anyone without experience in insect collecting. The larva, in fact, furnishes a good example of protective coloration. An individual would be in plain sight, and then if one's eyes were directed elsewhere for a moment it would sometimes be difficult to find it again, although it might be within a foot of the observer.

Larvæ obtained October 7 and later were kept feeding on asparagus in our rearing cages until the third week of October, when they descended to the earth and soon afterwards assumed the pupal condition. The exact date of the assumption of the chrysalis form was not ascertained, but it was about the 21st of October, which would give a period for the pupa of ten months, as the moths of this lot began issuing August 21.[a]

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[a] Bul. 10, n. s., Div. Ent., U. S. Dept. Agr., p. 60.

One individual transformed to pupa October 17 and the imago issued August 24 of the following year.

October 15, 1898, the larva was brought to the writer by Mr. P. H. Dorsett, from his greenhouse at Garrett Park, Md., where the species was feeding on the foliage of violet. The same year, November 3, this larva was found rather abundantly by Doctor Howard in tobacco fields in southern Virginia, near the North Carolina border line, upon the leaves, which in some cases were badly ragged.[b] The first moths issued in July.

During 1900 and 1901 correspondence was had in regard to this caterpillar with Mr. H. Walter McWilliams, Griffin, Ga., who sent specimens, as also larvæ of the so-called cotton cutworm (*Prodenia ornithogalli* Guen.), with which the insect was associated in both years. The caterpillars were noticed there in greatest numbers during November, and both species were reported as destroying a number of garden crops, among which were cabbage, collards, turnip, ruta-baga, rape, peas and related plants, as also some other vegetables. Mature larvæ were seen as late as the last week of November.

Among other office records are two which also have a bearing on the biology of this species. One of these was made by Mr. Theo. Pergande, who found the larvæ in the District of Columbia feeding on blackberry and on flowers of a goldenrod (*Solidago* sp.). The other is a short note by Mr. F. M. Webster upon the rearing of the moth in spring from the seed pods of milkweed (*Asclepias incarnata*), near Lafayette, Ind. "The larva appeared to subsist upon the seeds, the pods being attached unopened to the wrecked plant."[c]

October 21 the larva was found at Washington, D. C. We have no further records in regard to the habits of this species other than the capture of moths in the District of Columbia July 25, August 22 and 25, and September 2, and there are specimens also in the U. S. National Museum from Lewis County, N. Y., July 4, collected by O. Meske, and others from New Jersey without definite locality. The species is also said to occur at Portland, Oregon. It is interesting to note that among these specimens are inflated larvæ and mounted heads labeled "pretty cutworm," which might be termed a manuscript name, as I do not find this insect mentioned under this cognomen in print. With present knowledge of the species it can not properly be classified as a cutworm.

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[a] The rearing jar was kept under somewhat unnatural conditions, at times too warm and dry, but the effect of one condition might have been counteracted by another, and the date of issuance of the adults was not far from that which would be assumed in nature—more likely earlier than otherwise.

[b] Yearbook U. S. Dept. Agric. for 1898, p. 142.

[c] Insect Life, Vol. II, p. 382, 1890.

Among the files of the Department of Agriculture there are a few notes which are of interest as showing the cycle of periods from egg to about the last stage of the larva. These notes were made in 1882 by Mr. Albert Koebele, and the mounts which were made with them are not sufficiently fresh for description. From these notes the following is taken:

Moths collected at sirup, near the District of Columbia, September 16, were placed in a rearing jar with grass, where two batches of eggs were laid between 11 and 12 o'clock at night, one of these being deposited around the stem of grass.

September 18 the eggs hatched, showing the egg period to be only 2 days. On the 21st the larvæ had completed the first molt, making the first larval instar 3 days. September 23 the second molt was observed, which gives 2 days as the second larval instar. September 27 larvæ changed their third skin, leaving 5 days as the period of the third instar.

October 1 the fourth molt occurred, making 4 days for the fourth instar. By October 9 all the larvæ had changed the fifth skin, when they developed cannibalistic tendencies and were removed to a larger jar. The period of this instar was 8 days. The remaining larvæ refused to eat and finally died, so that the complete life cycle could not be ascertained.

NATURAL ENEMIES.

Soon after bringing larvæ in from the field some were noticed to be dying from fungous attack. In the asparagus fields *Estigmene* (*Leucarctia*) *acræa* Dru. and *Dissosteira carolina* L., the salt-marsh caterpillar and Carolina locust, respectively, were also dying in considerable numbers, and it was conjectured that the disease might have originated with these and spread to the Mamestras. After the diseased caterpillars had been frequently removed, however, the fungous attack abated. Specimens of infected larvæ were referred to the Bureau of Plant Industry, and the fungus was identified by Mrs. Flora W. Patterson, assistant pathologist, as an undescribed species of Verticillium. At another time larvæ which showed signs of disease after capture were examined by Mrs. Patterson, who recognized the presence of the fungus *Sporotrichum minimum* Speg. A larva, when placed with diseased insects, including some of its own species, did not contract the fungous disease, from which it seems probable that the disease is not readily communicable, and hence of no use as a possible means of destroying this species.

SUMMARY OF HABITS.

From present knowledge of the caterpillar two generations annually are indicated, although only one has been observed. Moths have been reared by the writer in July and August and they have been captured out of doors during the same months and in September. From available data it would appear that an average life history would be about as follows: Egg period, 3 to 5 days; first larval instar, 3 days; second larval instar, 2 days; third, 5 days; fourth, 4 days; fifth, 8 days, and pupal stage, 7 to 10 months. Hibernation occurs in the pupal stage.

The observed food plants include asparagus, cabbage, collards, turnip, ruta-baga, rape, peas and related plants, greenhouse violet, tobacco, grass, and blackberry. Of wild plants, golden-rod and milkweed have been observed, the larva attacking the flowers of the former and the seed pods of the latter.

METHODS OF CONTROL.

Although the early habits of this species as it occurs in the field have not been observed, there is no doubt that, like the zebra caterpillar, the young when first hatched are gregarious for some time, and hence may be easily discovered and destroyed by mechanical means or by arsenicals. All of the caterpillars of this class readily succumb to arsenical poisons, and for this species in its occurrence on asparagus and some other plants arsenate of lead is to be preferred. It may be used at the rate of about 1 pound combined with 15 to 25 gallons of water or Bordeaux mixture. If an adhesive resin soap, such as resin fish-oil soap, is added, it makes this mixture all the more permanent, and a single application is then all that is necessary. Paris green may be used in the same manner at the rate of 1 pound to 100 or 150 gallons of water. It is evident that this species, like the zebra caterpillar, does no particular harm as a rule in its first generation, but is much more abundant in the second or late fall generation, when certain plants are injured by it. Owing to the difficulty of locating the larger larvæ, it is evident that hand-picking would not be applicable for them in their later stages.

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L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE LEAFHOPPERS OF THE SUGAR BEET AND THEIR RELATION TO THE "CURLY-LEAF" CONDITION.

BY

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By E. D. BALL, Ph. D.,
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INTRODUCTION.

Ever since the introduction of the sugar beet into the intermountain region more or less loss has resulted each season from a condition called "curly-leaf," or "blight." (See Pl. I, fig. 1, *j*; Pls. II, III; Pl. IV, fig. 1.) Around Grand Junction, Colo., the beet growers have suffered frequent losses from this source. Supt. George Austin, of the Utah Sugar Company, reported a serious loss around Lehi, Utah, in 1897. In 1903 the beet crop in Sevier County, Utah, was somewhat injured, the next year the damage was worse and more widespread, while in 1905 it extended throughout the State of Utah and the adjoining portions of Colorado and Idaho.

Until 1905 the condition had been looked upon as a result of some fungous or bacterial disease, or due to a soil or climatic condition. During that season it was noticed for the first time that a leafhopper (*Eutettix tenella* Baker) was present in large numbers in the fields where this damage was the worst, and the writer, in connection with his duties as entomologist of the Utah Agricultural Experiment Station, commenced an investigation of the insect and its relation to the damage. It was then too late to work out its life history, so most attention was paid to a study of its relation to the "curly-leaf" condition and to experiments with remedies. This investigation was continued in 1906 and 1907, in cooperation with the Bureau of Entomology, and the life history was worked out. Owing to the small number of insects appearing these two seasons, little more was done with remedies, but many new facts were learned in regard to methods of attack and the causes of the injury.

The writer's attention was first called to the "curly-leaf" in August, 1900, by Prof. F. H. Shaw, then chemist of the Grand Junction (Colo.) Sugar Factory. A careful examination was made at this time and again in succeeding years, but no explanation was found for this condition. These examinations were, however, always made late in the season after the curly-leaf character had become general and after the greater number of insects had disappeared. Examination of the beets always revealed a few specimens of *Eutettix tenella* along with other leafhoppers and miscellaneous insects, but never in sufficient number to cause suspicion.

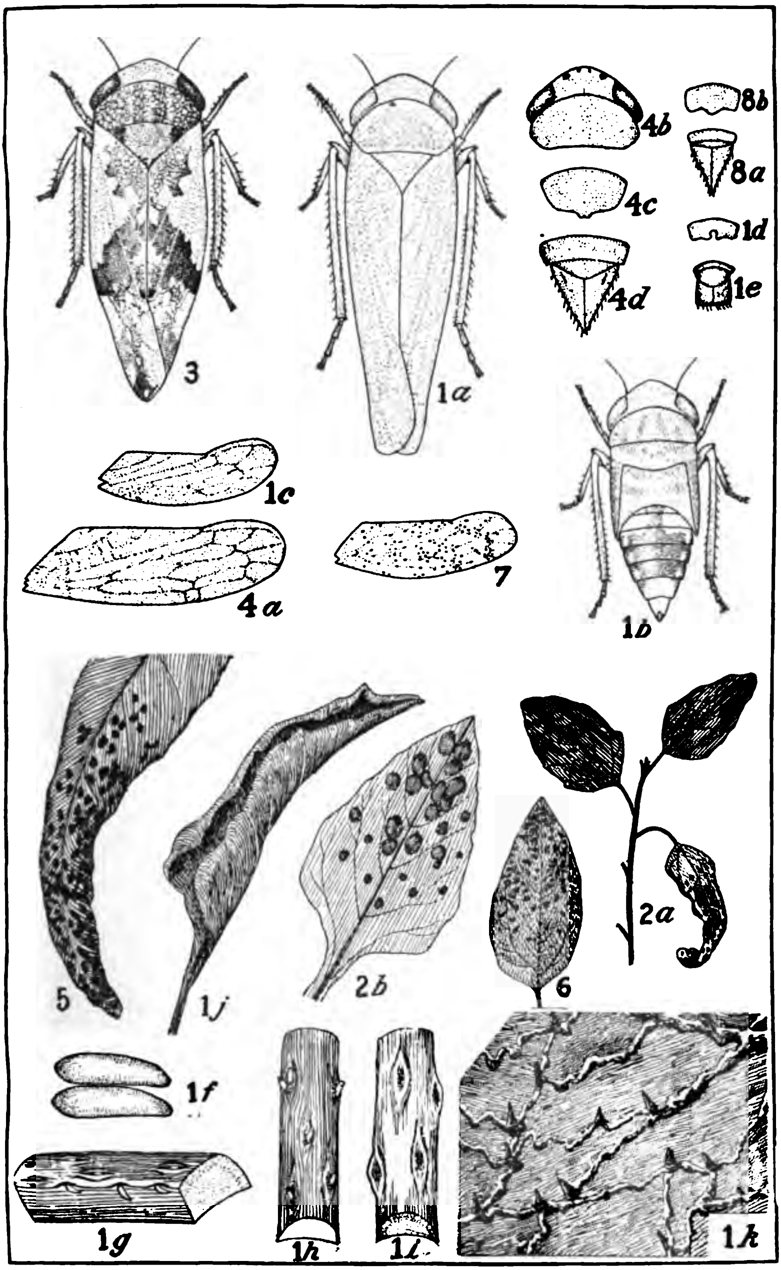
Late in June, 1905, reports began to come in to the Utah experiment station of the appearance of an insect in the beet fields of the southern and central portions of the State, and on July 8 the writer, in company with Mr. George Austin, visited the fields around Lehi and there found the beet leafhoppers, associated with smaller numbers of false chinch bugs (Nysius) and leafhoppers of the genus Agallia, causing serious damage to the young plants, especially in the late-planted fields.

From the size of the beets and the number of the beet leafhoppers present when first examined in 1905, the prediction was made that the insects would not be able seriously to retard the further growth of the beets. This prediction was based on the ordinary amount of damage done by insects of sucking habits. That the number of insects found would be able to injure or even seriously retard a very young beet was recognized, but that the same number could have any appreciable effect on large beets was contrary to all expectations based on a knowledge of similar attacks by Nysius, Agallia, and other sucking insects.

The trouble soon afterwards appeared in the Cache Valley, Utah, and was under observation there throughout the remainder of the season, while several trips were made to various parts of the State. Wherever it appeared it gradually grew worse, and although the year 1905 started with everything favorable in the early season, the Utah beet crop fell below the average about 75,000 tons. This, however, did not anywhere represent the entire loss, as both sugar content and purity of the beets harvested fell far below the average, entailing further loss to the sugar companies and bringing the total to more than half a million dollars.

In Sanpete and Sevier counties, in the southern part of Utah, a large part of the acreage was abandoned early in the season, while the rest barely paid the expense of harvesting. In Utah County the crop varied from a total loss on a few late fields to a full crop, with an average of more than a half crop harvested. In the Cache Valley, in the northern part of the State, the loss was about one-third in tonnage, and in Weber and Boxelder counties less than that.

In 1906 a very small number of leafhoppers appeared, and, as the season was cool, even where they were most abundant little damage was done. A careful study was made of the life history and distribution of the species, and a number of tests were made of its injury to the beets.



LEAFHOPPERS (EUTETTIX SPP.) AND THEIR WORK.

Fig. 1.—*Eutettix tenella:* *a*, Adult; *b*, nymph; *c*, wing; *d*, *e*, genitalia; *f*, eggs (greatly enlarged); *g*, section of beet stem, showing fresh eggs in place; *h*, same, showing eggs ready to hatch; *i*, old egg-scars on beet stems; *j*, small leaf of sugar beet, showing characteristic "curly-leaf" condition; *k*, enlarged section of back of an extreme case of "curly-leaf," showing "warty" condition of veins. Fig. 2.—*Eutettix strobi:* *a*, Work of nymphs on lambsquarters; *b*, work of nymphs on sugar beet. Fig. 3.—*Eutettix scitula:* Adult. Fig. 4.—*Eutettix clarivida:* *a*, Wing; *b*, head and pronotum; *c*, *d*, genitalia. Fig. 5.—*Eutettix nigridorsum:* Work of nymphs on leaf of Helianthus. Fig. 6.—*Eutettix straminea:* Work of nymphs on leaf of another Helianthus. Fig. 7.—*Eutettix insana:* Wing. Fig. 8.—*Eutettix stricta:* *a*, *b*, Genitalia. (Author's illustrations.)

THE BEET LEAFHOPPER.

(*Eutettix tenella* Baker.)

DESCRIPTIVE.

The adult (Pl. I, fig. 1, *a*) is a small, pale yellowish-green species, little larger than an Empoasca or Typhlocyba, with which it might easily be confused in the field were it not for the stouter build and greater activity. When fresh or when flying this leafhopper appears almost white, and for this reason it has often been called the "white fly." (Wing, Pl. I, fig. 1, *c*; genitalia, Pl. I, fig. 1, *d*, *e*.)

The eggs (Pl. I, fig. 1, *f*) are white, elongate, slightly curved and tapering at one end, and are thrust into the leaf stem in a slightly downward direction. At first they are scarcely visible (Pl. I, fig. 1, *g*), but as the stem grows they are pushed out with the opening up of the injured spot until at hatching time they are often half free (Pl. I, fig. 1, *h*). After the eggs hatch, the egg scars continue to enlarge and remain throughout the season as irregular, elongate, crater-like swellings (Pl. I, fig. 1, *i*). The eggs are deposited on all parts of the leaf stem, usually one in a place. In the cages they were often placed close together, very likely in this case by different insects, however, and a number were inserted into the midrib and secondary veinlets of the leaf and a few into the leaf margin near the base.

The nymphs (Pl. I, fig. 1, *b*) are very active, pale creamy white or variously colored forms. The commonest form is pale creamy in color with a brown saddle on the middle of the abdomen and various mottlings on the prothorax and wing-pads. Some have the same pattern with a reddish ground color, more are creamy yellow, and occasionally one is seen with a broad and somewhat irregular dark stripe down the back. When small the nymphs will be found most commonly down in the unfolding leaves at the center of the beet, but as they grow older they spread out over the plant.

FOOD PLANTS.

The original food plant of this species is still in doubt. In the spring it was found on greasewood (Sarcobatus), sea-blite (Dondia), several species of Atriplex, Russian thistle, and rarely on other plants of these two families occurring on the waste land. As these places dried up, most of the leafhoppers went to the sugar beets in the areas under observation. In one case, however, the species was found in some numbers on greasewood during egg-laying time, which would suggest this plant as its original host. Its known distribution is all within the area in which this plant is abundant.

DISTRIBUTION.

This leafhopper is apparently a native of the southwestern part of the United States. It has been collected from about the region of Denver, Colo., south along the edge of the mountains, through New Mexico, and west through Arizona, Utah, and southern Idaho to the coast in California and Oregon. Though confined to the mountain region, its distribution is restricted to the lower levels, and it is never taken on the mountains themselves. From this region it has not spread very far up to the present time. It was taken at Fort Collins and Lamar, Colo., in 1901—in one case 100 miles north of its known habitat, on wild plants, and in the other an equal distance east, but was rare in both situations. In Utah it has spread to the northern line of the State and into Idaho as far as that particular beet area has been extended, while it has not as yet been taken from the wild plants north of Ogden, Utah.

LIFE-HISTORY STUDIES.

Search was made for this species as soon as the growing season commenced in the spring of 1906, but no specimens were discovered in the Cache Valley, Utah, up to the time the beets came up. A trip to Sevier County, Utah, at the time the very earliest beets were just showing (April 22) failed to disclose a single individual, either in the beet fields or in waste places or hedgerows adjacent to the beet-growing districts. The first specimens discovered this season were found at Thompsons, Utah, May 3, feeding on Russian thistle, and a few days later the insect was found on the same plant and on an annual saltbush (Atriplex) at Grand Junction, Colo.

Beet fields were examined at Grand Junction, Colo., May 8, and in Utah at Lehi, May 9; Smithfield, May 12; Garland, May 13; Lehi, May 17; Corinne and Penrose, May 22; and Provo and Lehi, June 1, without finding a single leafhopper on any of them. The beets were not up at Lehi on May 9, nor at Smithfield, but the fields were examined carefully, especially where weeds were beginning to appear. Fields at Logan, Utah, were under observation during all this time and up to July 1, but no leafhoppers were found.

RECORD AT LEHI, UTAH.

On June 21 a field was examined at Lehi in which there was an average of one or two leafhoppers to a beet. They were all adults and two-thirds of them females. The beets in this field were from 6 to 10 inches across, and no sign of injury was observed. On examining the other fields in the valley a very much smaller number of leafhoppers was found. Some fields had one individual to 10 beets, while some had none at all. The average would not have been more than one leafhopper to 25 beets. They were most numerous on the higher, drier fields, and on the early beets. Two patches of very late beets close to the first one visited had no leafhoppers at this time.

Eight females from this field were dissected, and fully developed eggs were found in each one, 9 in one, 7 in another, and from 2 to 4 in each one of the others. Only large eggs could be seen with the lens used, and probably some of these were crushed while being removed. The fact that all females had fully developed eggs and that there were more females than males indicated that these adults had been out a long time and were not new ones of a brood that had just flown in from surrounding wild land.

On June 29 a few were found in the late beets, but no nymphs were found anywhere.

July 10 the adults were present in about the same numbers as before, the females still containing eggs, and a few very small nymphs were found.

July 23 the adults were slightly less numerous, and the nymphs from small to one-third grown and quite abundant. A few of them were nearly grown, but no fresh males could be found. More nymphs were found on the early beets, more "curly leaf" on the late ones.

August 3 the nymphs were mostly about two-thirds grown, some were small, and some full-grown. Large numbers of adults of the new brood were out, about half of the leafhoppers being adult at this time.

August 14 the adults were abundant. The leafhoppers were nearly all adults or large nymphs, but a few small nymphs were still to be found.

On August 29 the insects were mostly adult, males being still in the majority, but there was still quite a number of full-grown nymphs. Many females were dissected and a few found that had from 4 to 7 large eggs, but the rest had no sign of any. These few were probably the last remnant of the over-wintered brood of females.

September 12 the adults were still common and more males than females were taken by sweeping. Large nymphs were still present in small numbers. Ten females were dissected, but no eggs found, and the abdomens were all small. Evidently there was to be no egg laying for some time, probably not that season.

NOTE.—The season opened unusually late at Lehi in 1906, and these dates would be from one to two weeks late for an ordinary season.

RECORD AT MONROE, UTAH.

In Monroe, Sevier County, the season opened early, and the beets were nearly all planted in April. An examination April 22, as mentioned above, failed to discover a single leafhopper.

On June 26, on a second visit, nearly all the beets were in fine shape, with leaves touching in the rows, and only lacking a few inches of touching across rows. The leafhoppers were present in every patch, both adults and very small nymphs, and occasionally a larger nymph was seen. Mr. Fred Gould, field superintendent, said that he had observed the adults for some time. There were more leafhoppers on the older patches than on the late planted ones, indicating that they had migrated in before the younger beets were far enough advanced to attract them.

On July 25 the leafhoppers had increased in numbers, averaging from 10 to 20 to a beet on the earlier patches. Adult males were common, showing that the nymphs had commenced to change to adults again. All stages of nymphs were still common, however.

On September 14 the numbers of leafhoppers were beginning to decrease. Several countings gave an average of 7 males to 5 females and 5 large nymphs. The dissection of a number of females showed no eggs developed as yet, and there seemed little doubt that they would hibernate.

OTHER RECORDS IN UTAH.

A field belonging to a Mr. Irons at Moroni, Sanpete County, was visited June 27, and an average of one leafhopper to every two beets was found. Mr. Irons, who is a very careful observer, said that they had been there for some time. A careful search was made for the nymphs, but none was found. This was by far the worst infested field in the county, the average being less than one insect to ten beets.

July 26 adults and nymphs were about equally common, and few of either.

In the Cache Valley and the rest of the northern end of the State the leafhoppers did not appear in sufficient numbers to enable one to make any life-history notes. On this account all cage experiments were transferred to Lehi.

CAGE EXPERIMENTS, LEHI, UTAH.

The field observations on life history were all checked by cage experiments (Pl. IV, figs. 2, 3). Cages 1 to 3 were failures, through the adults escaping from the material used. Later a very fine silk scrim was used and proved satisfactory for the life-history work, but was too closely meshed to obtain normal temperature and moisture conditions inside. All cages were run in pairs on similar beets, one with insects and one without, as a check on the injury to the beet.

Cages 4 and 5 (glass globes upon beets about 8 inches in diameter).—On July 10, 16 adult leafhoppers, 12 of which were females, were introduced into cage 4. Previous dissections had shown that all females were bearing eggs, and the presence of a very few small nymphs in the field proved that the earliest ones began depositing eggs some time before. It was therefore expected that some of the females introduced would begin depositing at once.

On July 23 these cages were examined, and in the one containing the leafhoppers the stems were found to be fairly covered with egg scars. Two of the stems were removed and preserved, and found to contain 161 eggs—not more than one-sixth of the total number present. A number of females were seen in the cage, but no nymphs.

July 27 the stems showed still more egg scars, and there was quite a number of small nymphs that had apparently been out several days. The insects had been in the cage only seventeen days, so these eggs must have hatched within thirteen to fifteen days from the time of laying, under the conditions found in the cage. Another stem was removed and preserved, and the rest left as before.

On August 3 another stem was removed. The eggs had almost all hatched by this time. Some had dried up and a few were found just ready to hatch. A few were sticking out of the stalk and looked quite fresh, but were probably infertile. Some of the leaves had wilted and died, and the remainder were literally alive with small to half-grown nymphs, together with a few adults, no doubt the remaining parents.

These half-grown nymphs were no doubt those hatched between July 23 and 27, and would thus be between eight and eleven days old, roughly indicating a nymphal period of between sixteen and twenty-two days under these conditions.

On August 14 this cage was visited again, and the beet found dead and dry. From appearances it had been dead several days. The few leafhoppers that survived were adults and large nymphs. They were so few in number that it was impossible to tell whether they were the surviving parents or a new generation, so they were released.

Cages 6 and 7 (silk scrim 2 feet square).—On July 23, 18 nymphs varying between one-third and two-thirds grown were introduced into cage 6. These were intended to represent the larger ones found in the field at that date.

On July 27 no adults could be seen.

On August 3 most of the nymphs had changed to adults. This period of eleven days was, then, more than one-third and slightly less than two-thirds of the nymphal period. This gives about the same result as the test in cage 4.

Cages 8 and 9 (silk scrim with glass top).—On August 3, 40 leafhoppers were introduced into cage 8; of these 23 were females, apparently all fresh, 10 were males, and 7 were large nymphs, the aim being to get as many of the earliest ones of the maturing brood as possible without introducing any belated ones of the parent brood. By this method it was hoped to get the succeeding brood, if there was to be one, as soon in the cages as it appeared in the field, and thus establish a minimum time between broods.

On August 14 this cage was examined, and all leafhoppers seen were adults. There were no signs of egg scars or of damage.

On August 30 but few leafhoppers could be seen, and no egg scars or damage.

On September 12 the leafhoppers were almost all gone, and no eggs had been laid, either in the cage or field, and dissection showed that the females had no visible eggs in the abdomen up to date. It was thought at this time that the adults would lay eggs in the fall and then die. Accordingly a new lot was started, as shown below.

Cages 10 and 11 (large lantern globes).—On August 30, 30 leafhoppers were introduced into No. 10, of which 12 were females. In No. 11 one female and several males were introduced. On September 12 no egg scars could be found in either cage.

Cages 13 and 14 (silk scrim with a glass top).—On September 12, 20 leafhoppers, nearly all of which were females, were placed in cage 13.

On October 20 the field of beets was harvested. The cages were removed and the beets labeled and sent on for examination. Each leaf and stem, and even the parts of the beet itself protruding from the ground, were examined carefully, but no sign of any egg scars could be found on these beets or on those from the previous cages. Many of the leafhoppers were alive at the time the cages were removed, and there seems to be no doubt that they must hibernate as adults.

SUMMARY OF LIFE HISTORY.

By the time the beets were thinned the leafhoppers began to appear in the fields and by the middle of June were well distributed. They gradually increased in numbers for some time after this. Egg laying began at Lehi, Utah, late in June and continued until late in August, each female depositing about 80 eggs, the period of deposition extending through several weeks, the greater number of the eggs, however, being deposited in the ten days preceding the middle of July. The nymphs appeared in small numbers by July 10, and were still to be found in small numbers in September. A great majority of them emerged from the eggs the last ten days in July and changed to adults some twenty days later. The first adults appeared from these nymphs the last of July and continued to increase in number through August. The egg stage in the cage experiments was between thirteen and fifteen days; the larval stage between sixteen and twenty-two days.

ECONOMIC RELATIONS.

The first fact observed in 1905 was that different fields were affected very differently, and much time was spent in studying conditions in an attempt to discover just what combination of factors was necessary to produce the "curly-leaf," so fatal to the beets. Even in the worst fields examined there would be here and there a beet that was apparently untouched and growing as usual, while in the best fields only here and there could an affected one be found.

As a result of the season's observations there seemed to be little question that the "curly-leaf" condition was the result of the attack of the leafhoppers combined with the effect of a very hot, early season.

In many places it was noticed that along the edges of the fields where the beets had any shade—such as would be furnished by a hedgerow, or even by a vigorous stand of sweet clover on a ditch bank—there would be a marked difference for the first few rows. In Sevier County, where many of even the early-planted fields were abandoned and where the rest averaged from 2 to 4 tons per acre, one field was seen that did not show much damage and yielded 12 tons per acre. This field had a block of tall poplar trees on the south and a row of equally tall ones on the west side. In other places it was observed that the fields that were the weediest had better beets than those that had been well cultivated. Under ordinary conditions the results in all these cases would have been just the reverse, and the only explanation that seemed plausible was that the shade of the trees and of the weeds kept the ground from becoming quite so hot and thus allowed the beets to overcome the effects of the leafhoppers. In ordinary practice the beets are not irrigated until they have made considerable growth; thus the taproot is forced to descend for water, and a long, symmetrical beet results, while if watered too soon the beets are short and sprangly. In one place, in 1905, it was found that the water had escaped from a ditch and irrigated one corner of a field much earlier than it had been applied to the rest, and this corner was the only place that was not seriously affected with the "curly-leaf." In another place the water supply failed just as they started to irrigate the field, and the remainder was not irrigated until a week later. The difference in the amount of "curly-leaf" on these beets showed plainly to the end of the season just how far the early water reached. At first these differences were attributed to the effect of the early water on the beet itself, but on further investigation a number of fields was found where subirrigation was depended upon entirely and where, ordinarily, fine beets were raised. In these fields the taproots of the beets were found to extend into a stratum of saturated soil and yet the beets were badly affected and continued to grow worse throughout the season. The only explanation found for that condition was that, while the beet had plenty of water, still the top soil was dry and dusty, and the ground was as hot as in an ordinary field, while in the fields that were irrigated early the evaporation from the moist surface kept the temperature down until the beets were large enough to shade the ground. This would also explain the fact that everywhere in the State, except in Sevier County, the late beets were affected much worse than the early ones. In other portions of the State the early beets were large enough to shade the ground in the rows by the time the hot weather and leafhoppers appeared. In Sevier County, on the other hand, the hot, dry weather came on earlier and the leafhoppers were so much more numerous that even the earliest beets could not withstand their attack when exposed to the full force of the sun.

The unusual numbers of the beet leafhopper were apparently largely the result of a winter and spring favorable for the preservation of insect life, as almost all injurious insects were present in increased numbers during that season (1905). The leafhoppers had, however, evidently been increasing for several years and had even before this reached destructive numbers in Sevier County, as the beet growers there had been suffering increasingly from what they called "blight" for two years previous to this, and this increase in the number of insects, followed by a winter favorable to their survival, resulted in the outbreak of 1905.

The leafhoppers were present in every field examined in Utah that season, and occurred in the greatest abundance in the areas in which the "curly-leaf" was worst. The average number of adults of the over-wintered brood to a beet varied from 3 or 4 up to 10 or 15, and probably even more than that in Sevier County, judging from the number found there later. No serious damage was done where there were only the smaller numbers, and even where the damage was worst it seemed to depend more upon how early they appeared and the temperature and moisture of the locality at that time than on the actual number above an average of possibly 5 or 6 to a beet. In 1906 they appeared in very small numbers. The field at Lehi, Utah, where the experiments were conducted, was by far the worst found, and here they averaged only about 1 or 2 to a beet, while the average of the valley would not have been more than 1 to every ten or fifteen beets, and the average of the State was even less.

A field in Boxelder County, Utah, was examined in August, 1905, in which the leafhoppers had recently appeared in large numbers, averaging 100 or even 200 in some places to the beet. The beets were large enough then to shade the ground, and the field was well irrigated from that time on. Almost no curling of the leaves could be found in this field, and in the fall the yield was nearly up to the average. This was the only field examined in which the leafhoppers did not appear until after the adults had hatched out. On the other hand, many fields were examined in which the leafhoppers had been present early in the season but had almost disappeared after the nymphs had matured, and yet in these fields the curling continued to develop throughout the season and the beets grew worse instead of recovering.

Spraying with kerosene emulsion was tried on a field in the Cache Valley, Utah, in 1905. This field contained numerous adults and nymphs in all stages. Four nozzles were used, each one set about 18 inches above the row and pointing obliquely down and forward, and just in front of them a bar drew the beet tops over and caused the leafhoppers to jump just as the spray struck them. An emulsion diluted with 15 parts of water had little effect on the adults, and only killed a few of the smaller nymphs. Most of the nymphs would kick about on the ground and some would become quite still, but a little later most of them would recover and hop away. An emulsion diluted with 8 parts of water produced the same effect on the adults that the weaker dilution did upon the nymphs, and killed the majority of the nymphs that it struck. Many of the latter would, however, escape the spray on account of the broad leaves of the beet, and the results were not considered entirely satisfactory.

In the cage experiments it was expected that the number of leafhoppers necessary to cause "curly-leaf" on different-sized beets would be ascertained, but owing to the fineness of the gauze necessary to hold them the temperature and moisture could not be controlled and no "curly-leaf" was produced.[a] The damp conditions of the cages also made it difficult to keep the insects for any length of time.

In one experiment 16 leafhoppers, 12 of which were females ready to deposit eggs, were placed on a beet with a top 8 inches in diameter and consisting of a dozen or more leaves. Over another beet of the same size a check cage was placed. Seventeen days later the eggs had just begun to hatch, and already the beet in the cage without any hoppers was nearly twice the size of the first one. The beet on which were the leafhoppers continued to grow for a week or more, then practically stood still, and on the seventeenth day it was apparently smaller than when examined five days before. Seven days later a large number of nymphs had hatched out, the outer leaves were dead, and the rest looking sickly; ten days later than this the cage was examined again and the beet was dead and dry, while the beet in the check cage had again doubled in size. Twelve leafhoppers and their eggs stopped the growth of a beet in less than two weeks, and they, together with their progeny, killed it in less than two weeks more. The same number of adult specimens of Agallia, Nysius, or Empoasca would scarcely have made an impression on a beet of that size.

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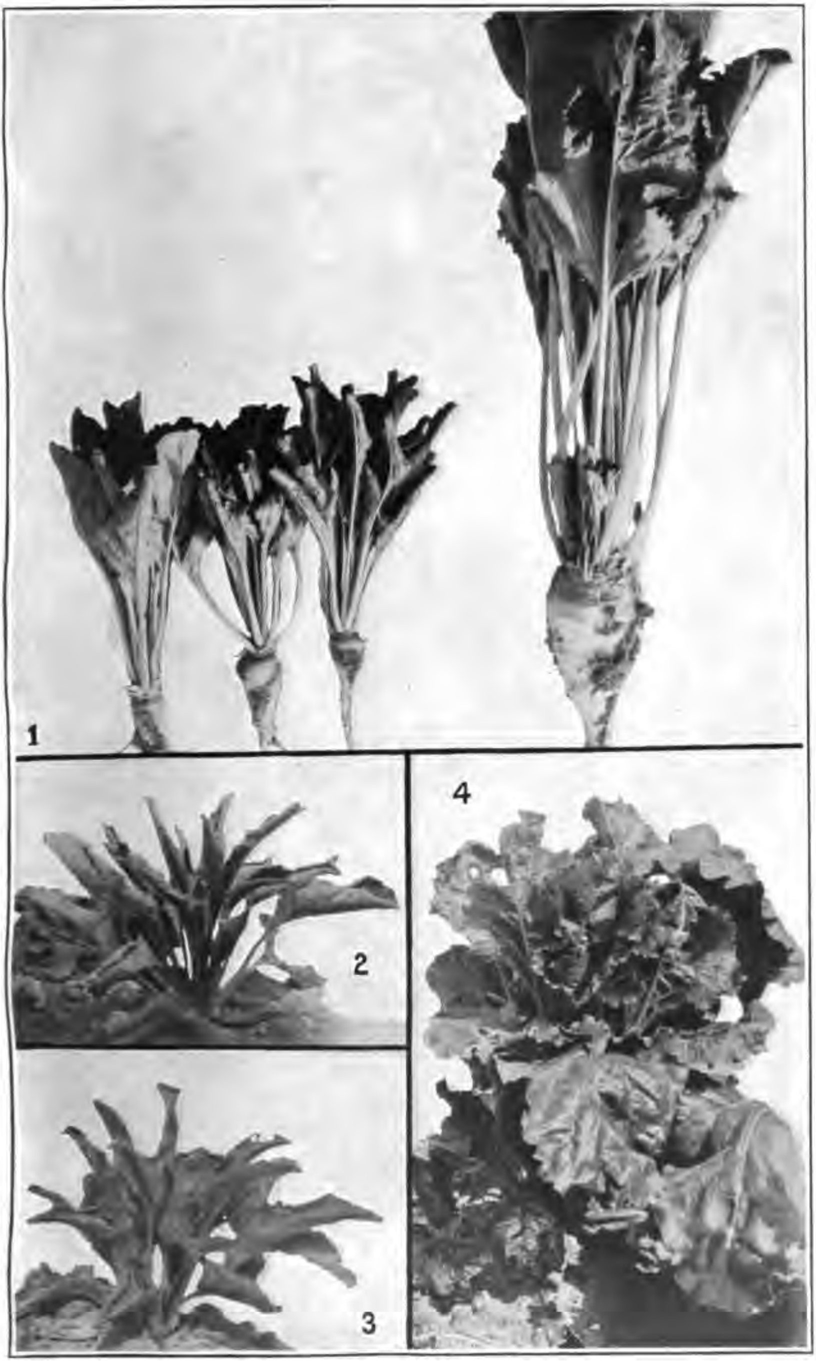
[a] This manuscript was originally prepared and submitted at the close of the season of 1906. Some revision was made to include the important facts of the work of 1907, but the main discussions, including the above paragraph, were written in 1906. Since that writing "curly-leaf" has appeared in cages arranged by Prof. E. G. Titus in joint investigations with the writer. Mr. H. B. Shaw, assistant to Dr. C. O. Townsend, in charge of Sugar Beet Investigations, Bureau of Plant Industry, U. S. Department of Agriculture, has also succeeded in producing "curly-leaf" under experimental conditions. He writes me under date of October 23, 1908, that curly top or "curly-leaf" appeared in the cages on the experimental plat at Garland, Utah, in which he introduced the beet leafhoppers, and that later he sent a number of leafhoppers to the office of Sugar Beet Investigations, Bureau of Plant Industry, where 6 of them were placed in a cage with 11 young beets, 9 of which showed distinct symptoms of "curly-leaf" within five weeks after the insects were introduced.

CHARACTERISTICS OF "CURLY-LEAF."

The first symptom of "curly-leaf" or "blight" of the beet is a thickening of all the smaller veinlets of the leaf, giving it a roughened appearance on the underside. This is followed by a curling of the edge (Pl. III, fig. 1) and a final rolling up of the leaf (Pl. I, fig. 1, *j*; Pl. II, figs. 2, 3; Pl. III, fig. 2), the upper surface always being rolled in. As this progresses the small veinlets grow still larger and more irregular, knotlike swellings appear at frequent intervals (Pl. III, fig. 2), and in extreme cases little nipplelike swellings appear, extending to a height of nearly one-fourth of an inch (Pl. I, fig. 1, *k*). This will be noticed first upon a medium-sized leaf, gradually spreading to the younger ones, while at the same time the beet almost stops growing and a large number of fibrous roots are sent out (Pl. II, fig. 1). These roots are not confined to two irregular lines as in a healthy beet. The beet often continues in this way throughout the season, in bad cases it shrivels and dies, while in a few instances there is a partial recovery and a new set of leaves, though the sugar content remains very low.

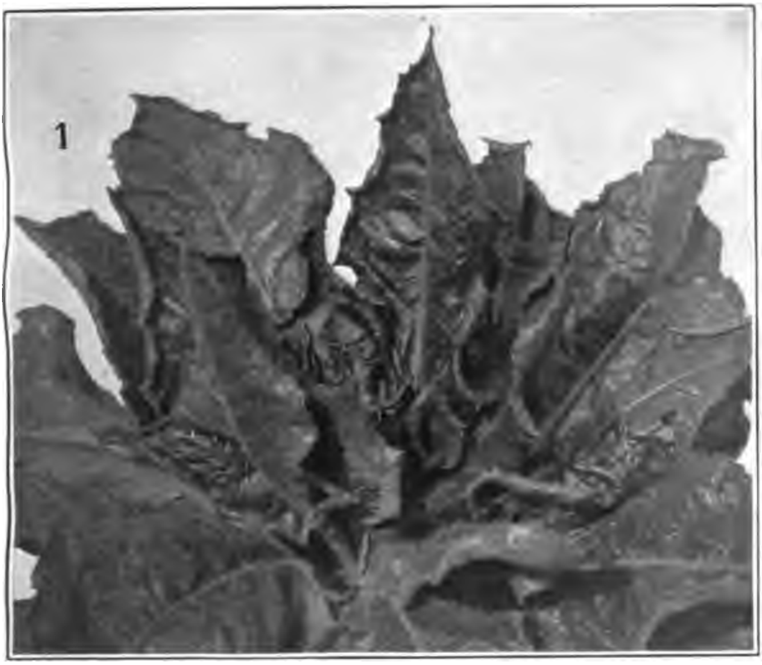
Many of the species of this genus of leafhoppers produce a discoloration or distortion of the leaves of their food plant. This appears to be of the same nature as the work of the gall-forming species, and is a process little understood. The wrinkling and folding of the leaves by some of the species is very similar in appearance to the work of some gall-forming aphides. Some species also produce a change in color similar to that produced in many galls.

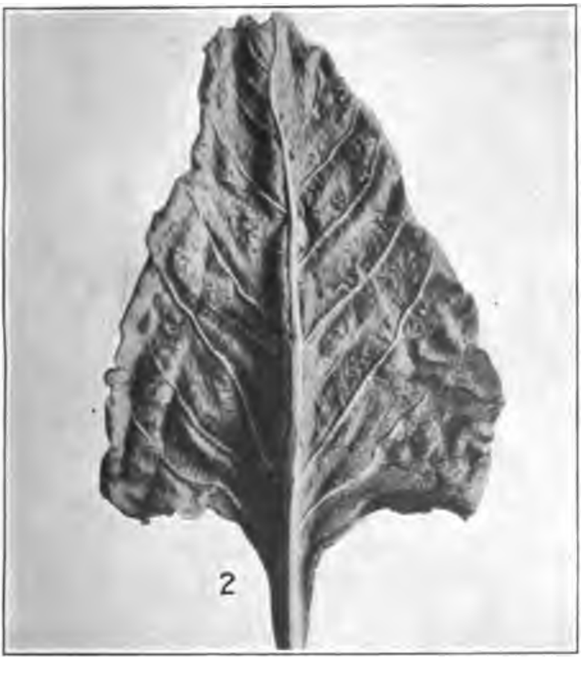
In the case of *Eutettix strobi* (Pl. I, fig. 2 *a*, *b*) and *E. scitula* on the Chenopodium or on the sugar beet and of *E. nigridorsum* and *E. straminea* (Pl. I, fig. 6) on the Helianthus the discoloration appears as



WORK OF EUTETTIX TENELLA ON SUGAR BEET.

Fig. 1.—Three "curly-leaf" beets, the result of attack by *Eutettix tenella*, and one normal beet from the same field, showing difference in size. Figs. 2, 3.—"Curly-leaf" beets as seen in the field. Fig. 4.—Normal beets from same field. (Original.)





WORK OF EUTETTIX TENELLA ON SUGAR BEET.

Fig. 1.—A large beet becoming "curly." Fig. 2.—Back of a leaf affected by "curly-leaf," showing "warty" condition and curled edges. (Original.)

soon as the little nymphs begin to feed, and this is soon followed by the distortion of the leaf in a certain definite way in each case. That this is not caused by the mechanical injury of the puncture or due alone to the loss of sap seems to be abundantly proved by the fact that the Chenopodium is often attacked by other sucking insects in much larger numbers without producing either the red pigment or the gall-like distortion. The fact that a certain characteristic color and appearance are always produced by a given species, no matter whether on a Chenopodium or on a sugar beet, and that the color and form vary for the different species of the same genus even when working on the same plant, would indicate that there is some definite agency back of it all. It has also been noticed that in all this group the greatest amount of damage is done in hot, dry situations.

Whether or not the "curly-leaf" condition is entirely the result of the change in the beet caused by the attack of the beet leafhopper is still an open question, but that there is some relationship between the leafhopper attack and the "curly-leaf" does not seem to admit of a doubt in the light of the facts brought out in the investigations. The amount of damage in a given valley was directly proportional to the number of leafhoppers present, the injury appeared only after the appearance of the leafhoppers, and the "curly-leaf" condition is known to occur only on beets growing within the range of this insect.

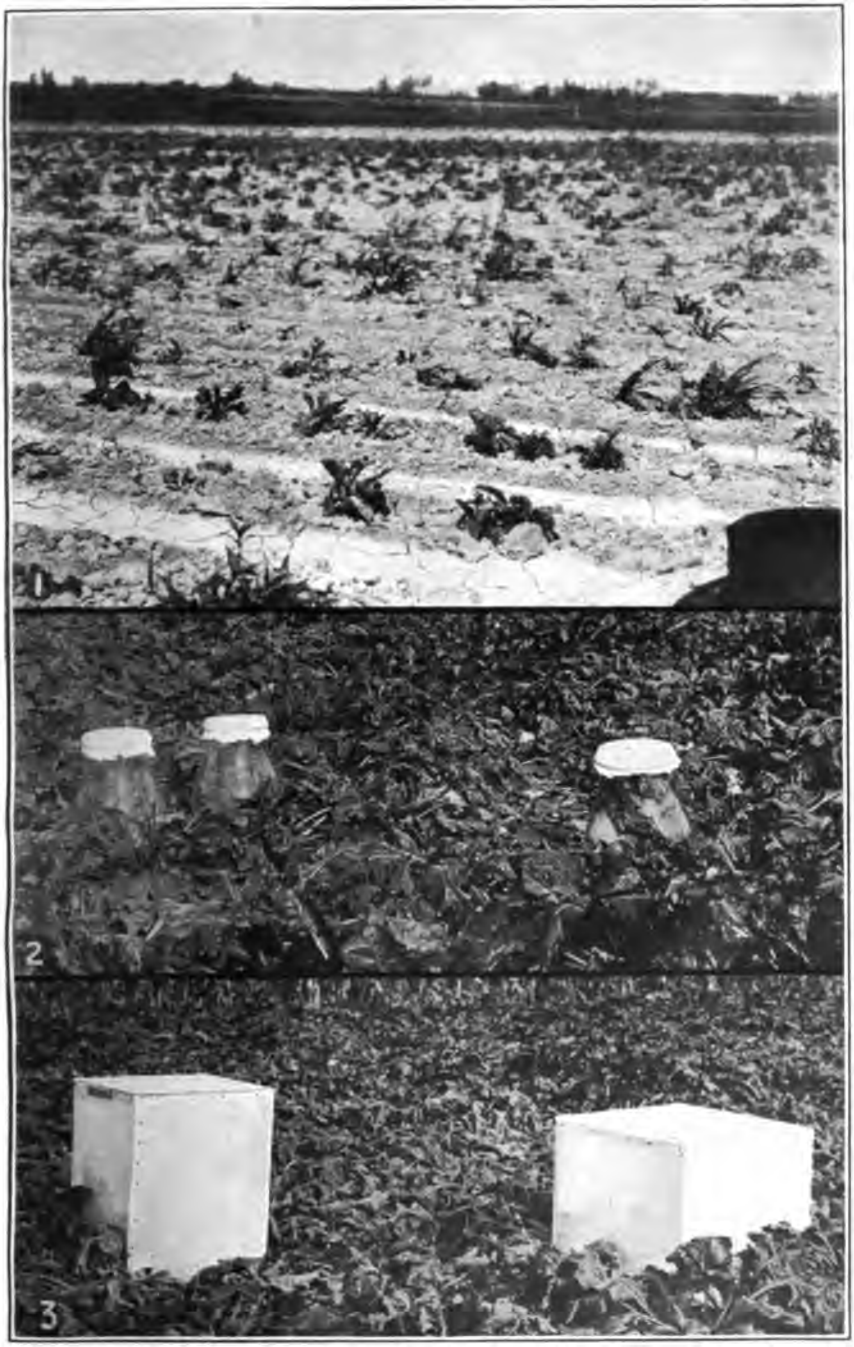
Attention was not called to the damage early enough in 1905 to ascertain whether or not the "curly-leaf" appeared before the first appearance of the nymphs. At Lehi, Utah, the "curly-leaf" appeared very soon after the first nymphs. In the Cache Valley, Utah, the nymphs were common by the time the first curling was noticed. In 1906 very careful watch was kept in all parts of the State for the very first sign of leaf-curl, and in no case did it appear (except on the mother beets) until after the nymphs began to hatch out. In fact, in almost every case examined the cast skins of nymphs could be found on the back of curled leaves, while on healthy beets these were very seldom found. In all observations of both years more leafhoppers were found on the curled beets than on others. At first this was thought to show a gregarious habit in the adult, but it may be due to the fact that a given female lays most of her eggs on a single plant and the nymphs tend to remain there. In *Eutettix strobi* and the other leaf-curling forms, where the nymphs are brightly colored and depend on their discolored spots for protection, it is not unusual for a given nymph to pass its whole life on a single leaf, or on two or three adjoining ones; in most cases but a single nymph will be found on a plant, and sometimes the adult and the nymphal skin of each stage may be found under a single leaf. It is very likely that the same habit persists in *Eutettix tenella* and that this fact, in part at least, accounts for one beet being badly affected while the adjacent ones are unharmed. In the case of *Eutettix strobi* and its allies, where most of the leaves of a small plant are affected by the distortion, the plant usually shrivels up and dies, but where only one or two leaves on a large plant are distorted the plant does not appear to be affected at all, and in no case does the color appear in any of the new leaves. In several cases small beets have been seen in which every leaf has been deformed by the work of *strobi*, and they had apparently stopped growing.

In the case of the "curly-leaf," however, the abnormal condition apparently spreads from leaf to leaf until finally the whole plant is affected, even though the leafhoppers may have disappeared before the process is complete. This was abundantly demonstrated by the mother beets set out in the spring of 1906. These beets were selected from the best-looking beets of 1905, and would naturally have been ones that showed little or no effect of the "curly-leaf" the season before. In every case observed the first leaves sent up by these beets were as curly as the average of the year before, and most of them formed stunted lettucelike heads, and later withered and died. Some, however, survived through the season, and a few sent up stunted blossom stalks, but as a seed crop they were an entire failure. This curling took place before any leafhoppers were found in the beets, and in rows adjoining young beets that were not at all affected and did not become affected during the season. This would indicate that the agency, whatever it may be, that causes "curly-leaf" remained in the beet itself over winter and was transmitted to the first leaves in the spring.

In early September, 1907, the sugar-beet region around Spreckels, Cal., was visited by the writer and a number of cases of what was commonly called "blight" or "curly-leaf" were examined. These, however, proved to be quite different in character from the "curly-leaf" condition caused by *Eutettix tenella.* The leaves of the beet were found to be covered with pale spots, the edges were turned down instead of up, and the whole appearance was quite different. A careful search was made over many acres for specimens of *tenella*, but none was found; instead a species of Empoasca was always found associated with this appearance of the beets. The matter will be discussed further in connection with that species (p. 51).

OTHER RECORDS.

Prof. E. G. Titus reports that on a trip through the sugar-beet regions of the West in September, 1904, he found *Eutettix tenella* at La Grande and Echo, Oreg. At La Grande little damage was done, while at Echo one field of 10 acres was so seriously injured by what



WORK OF EUTETTIX TENELLA ON SUGAR BEET.

Fig. 1.—A field of beets destroyed by "curly-leaf." **Figs. 2, 3.**—Cages used in the life-history experiments. (Original.)

was then called "blight" that it was not harvested. Many of the beets had died and the rest were small and stunted, while the leafhoppers could be swept up in numbers.

In California "curly-leaf" conditions were seen by Professor Titus at Oxnard and Spreckels and reported to be quite serious on the higher lands back of Salinas. Whether this was the true "curly-leaf" or the type found there this year was not determined.

In August, 1907, another trip was made by him through the same territory and a few specimens of *Eutettix tenella* taken at Payette, Idaho. Little damage was being done that season, but field men reported considerable loss in 1905 in both Payette and Blackfoot, Idaho. A few *E. tenella* were taken at Union, Oreg., and Echo, Oreg., in August, 1907, only slight damage showing in either place. Large nymphs were taken with the adults.

In California a number of places were visited by Professor Titus in August, 1907, but no specimens of Eutettix taken. In September another trip through the California districts was made, and a few specimens of *E. tenella* were taken at Chino on the 13th. No very definite cases of "curly-leaf" were noticed.

ECONOMIC SUMMARY AND PROPOSED REMEDIES.

The "curly-leaf" condition or "blight" of the sugar beet, as it occurs in Utah and the surrounding region, appears soon after an attack of the beet leafhopper (*Eutettix tenella* Baker). Its severity is conditional upon the number of insects present, upon the time of their appearance, upon the size of the beets, and upon the temperature of the surface soil, together with the temperature and moisture of the surrounding air.

More should be known about the places of hibernation and early spring history of this insect. It could not be found in the rubbish around the fields in early spring, and only a few specimens were found in waste places up to the time they appeared on the beets. When once the place where the greater number of them pass the winter is discovered, it may be possible to destroy them there or on their spring food plants before they migrate to the beets. After they have appeared on the beets it will be necessary to be very prompt in the matter of remedies if the injury is to be prevented. A thorough spraying with kerosene emulsion at a strength of 1 part of the stock solution[a] to 5 parts of water would destroy most of the insects that it hit, and by using a drag in front of the nozzles to turn the leaves over and cause the insects to jump, most of them could be reached. Where the insects were coming in in numbers this spray would need to be followed by a second one 10 days later.

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[a] For directions regarding the preparation and use of kerosene emulsion see Farmers' Bulletin 127, U. S. Dept. of Agriculture, pp. 20–21, and Circular 80, Bureau of Entomology.

Several mechanical devices have been used to catch different leafhoppers, and no doubt several of these could be used against this insect with advantage. The tar pan, or "hopper-dozer," drawn over the beets two or three times in the first few weeks would capture a large number of them. The females, before the eggs are laid, are quite heavy and do not jump or fly as readily as the males and would be easily caught. A modified form of this machine, consisting of a couple of tarred wings to be drawn along on each side of a row of beets, while a drag agitated the tops and caused the insects to fly, would probably capture more than the simpler tar-pan.

If the insects appeared while the beets were quite small, they could be largely destroyed by rolling when the weather was cold or damp and the insects sluggish.

A number of preventive measures may be used to assist the beets in withstanding the attack of the leafhoppers. In some sections early planting will produce beets large enough to shade the ground by the time the beet leafhoppers appear, and thus reduce the temperature below the danger line. In a few places, like the Grand Junction district in Colorado and Sevier County in Utah, early planting alone would not avail, as the insects appear soon after the earliest beets come through the ground. For such sections early and frequent irrigations would assist in keeping the ground cool until the beets grew large enough to shade it and thus take care of themselves.

All preventive measures will depend for success upon some method of controlling the temperature in the field so that the ground may not be hot and dry at the time the leafhoppers appear.

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OTHER LEAFHOPPERS.

Seven species of leafhoppers of the genus Eutettix besides *tenella* are known to have definite food plants related to the sugar beet, and several more, the food plant of which is not known, will probably be found to have similar habits. All of these species will no doubt be found on the sugar beet as fast as its cultivation is extended into the regions where these insects occur. The following species of Eutettix are already known to occur on the beet, and are arranged in about the order of their present importance.

Eutettix strobi Fitch.—The nymphs of *Eutettix strobi* are thickly spotted with red, giving them a strongly reddish appearance. They are found on *Chenopodium album* (Pl. I, fig. 2, *a*) and are confined strictly to the underside of the leaf. The attack produces a red discoloration and a curling of the leaf, which serves as a double protection for the insect. There are two broods in a season, the nymphs appearing in late May and early June and maturing from the middle of June into July. The adults of this brood are common from the middle of June through July. Nymphs appear again late in July, from which adults appear late in August, and more commonly in September. This species was carefully studied through the first brood in 1906. Then the area under observation was pastured and the record lost. The Colorado records agree with last year's work for the first brood, and furnish data for the second one. Prof. Herbert Osborn[a] first called attention to the red coloring of the leaves. It has been noticed many times since. This is, no doubt, the *Allygus* sp. of Bruner.[b] Forbes and Hart have mistaken the nymph for that of *Phlepsius irroratus* Say.[c] The larva of *P. irroratus*, however, is brownish and fuscous and lives on the ground. *Eutettix strobi* has been found on beets (Pl. I, fig. 2, *b*) in a number of places in Colorado and Utah, nearly all of them, however, around the margins of fields. In one place the insects had appeared on the beets when they were quite small, and had been numerous enough to deform every leaf on a number of beets and entirely stop their growth.

Eutettix scitula Ball (Pl. I, fig. 3).—*Eutettix scitula* is a white species with a brown saddle and brown pronotum. The nymphs are of a powdery pink color and live on the underside of the Chenopodium leaf in the same way that those of *Eutettix strobi* do, except that the discolorations are lighter. This species is apparently two-brooded. The first brood has been carefully worked out, but only adults have been observed in the fall. The broods appear about the same time as those of *E. strobi*. This is a western species occurring in Colorado and Utah and has been found on sugar beets only at Grand Junction, Colo. The adults of the species are almost invariably found on poplar trees, and it seems probable that the eggs are deposited on twigs of the trees and that the nymphs drop to the ground to find a home on the Chenopodium. The adults of *Eutettix strobi* and *E. seminuda* are often found on trees and may have the same habit. In the case of *E. strobi* and *E. scitula*, nearly all instances of bad infestation have been near trees. In the case of *E. scitula* these have been poplars, but two of the worst instances of injury from *E. strobi* were alongside apple trees.

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[a] Science Vol. X, p. 166, 1887.

[b] Bul. 23, o. s., Div. Ent., U. S. Dept. Agric., p. 17, 1891.

[c] Bul. 60, Ill. Agric. Exp. Sta., p. 424, 1900.

Eutettix seminuda Say.—*Eutettix seminuda* is a white insect with a brown saddle. It occurs from Kansas east to the Atlantic coast. The nymphs are pale, with a brown saddle on the abdomen and some brown on the thorax. Nothing is known as to their native food plant, but from the close relationship to the preceding species it is likely that it will prove to be a Chenopodium. There are two broods in a season, the first one appearing slightly earlier than in the case of *E. strobi*. *Eutettix seminuda* has been reported on beets in Illinois. It does not occur in the West, where the writer has worked on beets.

Eutettix clarivida Van Duzee (Pl. I, fig. 4, *a*, *b*, *c*, *d*).—*Eutettix clarivida* is a green species with four black points on the margin of the vertex. It occurs very commonly on the shad scale (*Atriplex confertifolia*) and on one or two other species of the same genus in the arid regions. It has been found on beets at Grand Junction, Colo. The nymphs are green, with two black spots on the vertex. The life history is not known.

Eutettix insana Ball (Pl. I, fig. 7), *E. albida* Ball, and *E. pauperculata* Ball occur on different species of Atriplex in the arid regions, and may be expected to occur on the beets.

Eutettix stricta Ball (Pl. I, fig. 8, *a*, *b*) is an Arizona species and the nearest relative of *E. tenella* that we know. There is probably more danger from this than from any other species of the group, if the sugar beet should be introduced within its range.

All the species of Agallia in a given section will be found attacking the sugar beet more or less. Several of the species seem to be almost omnivorous in food habits, but where they do show a preference it is for the relatives of the beet. For two of the species (*cinerea* and *bigeloviæ*) a definite food plant is known, and in both cases they are close relatives of the beet. The species of Agallia are divided into two groups, based on structural and life-history characters. In one group, which includes *sanguinolenta*, *uhleri*, *cinerea*, and *bigeloviæ*, they seem to prefer warm and rather dry situations, the adults hibernating and spreading over the beet fields in the spring in time to lay their eggs and produce their single brood of young there.

Agallia sanguinolenta Prov. is the most abundant species of the genus in the western country and is found in all fields. Together with *A. uhleri* this species has been observed to do considerable damage in the Arkansas Valley, in Colorado, and around Lehi, in Utah. The nymphs appear early in June and mature in the last half of July and the first half of August, a few running on through the month.

Agallia cinerea Osborn and Ball is found almost exclusively on the "shad scale" of desert regions, and from this adults often fly to near-by fields of beets. It was common at Grand Junction and Loma, Colo., and at Monroe, Utah. Under the hot desert conditions the nymphs appear in June and mature the last half of July, while on the beets they do not mature until some time later.

Agallia bigeloviæ Baker occurs in abundance on a tall species of sea-blite (Dondia) growing on alkaline soil, and has been found in the beet fields at Grand Junction and Palisades, Colo.

Agallia quadripunctata Prov. and *A. novella* Say belong to the other group of the genus and pass the winter as partially grown nymphs, which change to adults in late May and June. The nymphs appear again in August and develop slowly until fall, when they hibernate. These two species and *A. sanguinolenta* are discussed by Osborn and Ball (Iowa Experiment Station Report for 1897, p. 112), the nymphs and adults being figured and the life histories given. The dates given there are, however, too early for western conditions. This group thrives best in damp situations where rank vegetation abounds, and will not do any serious damage to beets unless planted alongside places of this character, from which the nymphs can migrate in early spring. By the time the adults are mature and ready to fly, the beets are well started and beyond their injury.

Empoasca sp.—A large number of adults of a small green *Empoasca* were found on sugar beets at Spreckels, Cal., in early September by Prof. E. G. Titus and the writer. The beet crop was not seriously injured, but a number of beets were found in which there was a slight curling of the leaves resembling "curly-leaf," except that in this case the edges of the leaf turned down rather than up, and the surface of the leaf, instead of being roughened, was covered with small pale spots. This pale spotting of the leaves is quite characteristic of the injury of the Empoascas and their relatives and is commonly seen on apple and rose leaves. The insects were all adults at this time, so that it was impossible to be certain that they had bred on the beets, but from the appearance of the leaves it is probable that they had. The nymphs of nearly all of this group are slender, pale-greenish forms and are found mostly on the underside of the leaf, while the white spots caused by their punctures show more plainly on the upper surface.

Professor Titus reports finding an Empoasca common on beets at Chino, Cal., in August, 1907, and states that the beet leaves showed the characteristic spotted appearance, but that no curling was noticed. In his trip in 1904 Empoascas were noticed in several places in California, and quite serious damage from "blight" or "curly-leaf" was found in a few places, but the particular nature of the injury was not observed.

The Empoascas nearly all pass the winter as adults, hibernating in rubbish and sheltered places near their food plants. In the spring they feed on anything that offers until their food plants start, and then they gather on them, laying eggs in early summer. The young nymphs feed on the underside of the leaf and are quite active and keep out of sight.

Spraying with kerosene emulsion, 1 part of the stock solution to 8 parts of water, proved to be a satisfactory remedy for an Empoasca on potatoes in Iowa some years ago, and no doubt could be used on the beets with success. Burning off rubbish around the field in the late fall would probably reduce their numbers.

CONCLUSIONS IN REGARD TO "CURLY-LEAF."

As a result of the above investigations, it appears that there are at least two distinct kinds of "curly-leaf" that have been confused under one name. One, in which the leaves become rough and warty and curl up and in which the beet is stunted and does not recover; the other, in which the leaves remain smooth but show numerous pale spots and in which the edges turn down, and in which, as far as known, the injury is confined to the leaves attacked. The first-mentioned kind of "curly-leaf" occurs from Grand Junction, Colo., west to the Pacific coast and is the one that has been seriously injurious in the intermountain region. This condition is brought about by the attack of the beet leafhopper (*Eutettix tenella*), and will, no doubt, be confined, for some time at least, to the southwestern part of the United States, the native home of this insect. The second kind of "curly-leaf" has been found in California quite commonly, and doubtless will be found to occur sparingly at least in the eastern part of the United States, or wherever an Empoasca attacks the sugar beet.

Besides these two types of this injury it is quite possible that in rare cases other types with still other causes have been seen and not recognized at the time as distinct. Investigations in the California field have been so meager that it is impossible to say as yet which type has caused the greatest injury. In the intermountain region, where most of the work has been done, practically all the injury is known to have been caused by the first type.

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L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE SEMITROPICAL ARMY WORM.

BY

F. H. CHITTENDEN AND H. M. RUSSELL.

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ERRATA.

Page 65, line 15 from bottom, for *fresh air-slaked* read *freshly slaked.*
Page 68, line 8, for *6* read *50.*

U. S. D. A., B. E. Bul. 66, Part V. Issued January 28, 1909.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE SEMITROPICAL ARMY WORM.

(*Prodenia eridania* Cram.)

By F. H. Chittenden and H. M. Russell.

INTRODUCTION.

During the summer of 1907 a smooth or hairless caterpillar (*Prodenia eridania* Cram.) related to the cotton cutworm came under the observation of the junior author at Orlando, Fla. It was observed attacking the foliage and, in many cases, the stems and fruits of all forms of garden truck grown in that vicinity, the list including tomato, potato, sweet-potato, eggplant, pepper, okra, collards, and cowpeas. The infestation was of considerable severity, and great injury was done in fields and gardens in that and in some other regions of Florida, notably at St. Augustine and on the west coast of the Manatee River. What is believed to be the same species was reported injurious in Porto Rico by Mr. W. V. Tower. Aside from a brief notice which has been made of the present invasion there does not appear to be any other record of the injurious habits of this species; hence the following account has been prepared for publication by the senior author. The chapters on recent injuries, natural enemies, and experiments with remedies have been compiled from the junior author's notes. The technical descriptions of the egg and larva have been prepared by Dr. H. G. Dyar, while other assistance in the preparation of this article is duly acknowledged in its proper place.

In ordinary seasons the species under consideration confines itself largely to weeds, among which are the poke-weed, spiny amaranth or careless weed of the South, and a wild Solanum. It has habits different from those of the northern cutworms and can scarcely be classified with the climbing cutworms, although it has the climbing habit. It has a decided tendency to travel in armies like the army worms and is practically confined to semitropical regions. It is remarkable as being injurious throughout the warm season and breeding continuously, there being evidently at least four generations a year in nature.

DESCRIPTIVE.

The adult is a noctuid moth, and while the larva is quite readily referable to the genus Prodenia, the moth has little of the appearance of our other two North American species.[a]

The moth.—The adult or moth has a wing expanse of nearly 1½ inches (33–38^{mm}); the fore-wings are dull gray, sprinkled and dotted with brownish and black scales forming a pattern as shown in figure 8, *d.* There is considerable variability in these markings, some individuals having a strongly marked reniform spot, a very prominent blackish posterior marginal line, and a similar black line on the latero-posterior margin. Individuals also occur in which there is a straight, broad, jet-black dash or band beginning at the middle of the fore-wing and extending to the lateral margin. This is the *nigrofascia* of Hulst. The hind-wings are pearly white above, this pearly luster being still stronger below. The body is brownish gray and the antennæ are yellowish brown.

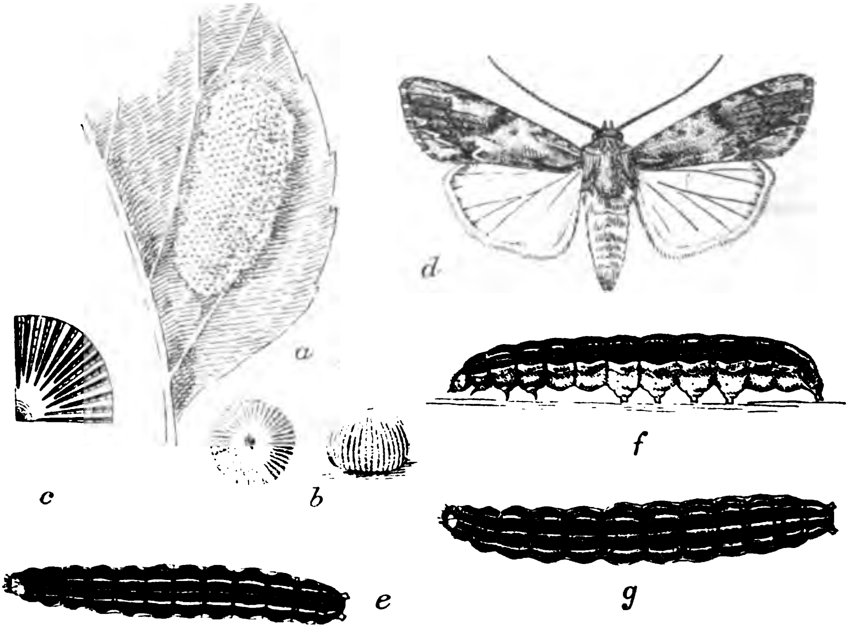

FIG. 8.—The semitropical army worm (*Prodenia eridania*): *a*, Egg-mass on leaf; *b*, egg, much enlarged, showing lateral view at right and top at left; *c*, section of egg: *d*, moth; *e*, dark form of larva nearly grown: *f*, *g*, larva, full-grown. *a*, *d–g*, Enlarged; *b*, highly magnified; *c*, more magnified. (Original.)

The darkest forms of this species are marked very much as in the genus Acronycta.

The eggs.—The eggs are deposited in irregular masses, as shown in figure 8, *a*, closely placed together, sometimes in two layers and covered with whitish down, from the body of the female. They are distinctly green when first deposited and have the appearance illustrated at *b* and *c*.

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[a] *Prodenia ornithogalli* Guen. ("cotton cutworm") and P. *commelinæ* S. & A.

The larva.—The caterpillar resembles that of the other two species of Prodenia sufficiently to be naturally referred to that genus, and it is subject to similar variation in color. The ground color is dark grayish in pale individuals and nearly black in the dark forms. These latter, especially when approaching maturity in the penultimate stage, are sometimes so dark as to resemble Mamestra. The body is ornamented with a narrow, slightly interrupted, median yellow longitudinal dorsal stripe, a similar slightly wider dorso-median stripe, and a wide and brighter yellow substigmatal stripe, which becomes obscured in the thoracic segments of the penultimate stage. In the very dark forms the triangular velvety dorsal spots characteristic of the genus can scarcely be seen, and in the paler forms they are seldom as distinct as in the other two species. When full-grown the larva measures about an inch and a fourth to an inch and a half in length (25–37^{mm}), and the width varies from one-fourth of an inch to a little larger. The head measures nearly 2.5^{mm}.

The mature larva is illustrated at *f* and *g* of figure 8 and a dark form nearly grown at *e*.

The pupa.—The pupa resembles closely that of *Prodenia commelinæ*. The head and abdomen are well rounded. The color is mahogany-brown, with the head, spiracles, and anterior edges of the abdominal segments darker. The surface is smooth and shining, with the anterior edges of the abdominal segments finely punctured. The anal segment terminates in a two-spined cremaster-like process. Length, 16–18 ^{mm}; width, 5–6 ^{mm}; length of head to end of the wing-cases, 10^{mm}.

The following technical description of the egg and larval stages was kindly contributed by Dr. H. G. Dyar.

TECHNICAL DESCRIPTION OF THE EGG AND LARVAL STAGES.

The egg.—Hemispherical, smooth, pale green, shining; ribs very fine, obscure, numerous, ill-defined, radiating from the micropyle; cross-striæ imperceptible. Diameter, 0.6^{mm}. Laid in a patch, covered by a thin layer of whitish wool.

Stage I.—Head rounded, bilobed, mouth pointed, shining greenish-black; eyes black, mouth brown; width about 0.3^{mm}. Body robust, uniform, joint 12 slightly enlarged, feet of joints 7 and 8 a little smaller than the others and not used in walking; translucent greenish, cervical shield, leg plates, thoracic feet, anal plate, and the large round tubercles shining black; tubercles i and ii of joint 12 in a square; setæ rather coarse, moderate, black, simple.

Stage II.—Head rounded, slightly bilobed, the vertex level with joint 2, shining luteous, blackish shaded over the vertices of the lobes; ocelli black, mouth brown, width, 0.4^{mm}. Body somewhat thickened at joints 5 and 12, feet normal, equal; greenish luteous, cervical shield and anal plate blackish infuscated;

tubercles rather large, low-conical, black; leg shields slightly smoky; tubercle vi present; a large red blotch around tubercles i and iv on joints 5 and 12; setæ short, black, stiff; traces of a white dorsal line showing especially by the cut between the red blotches at tubercle i of joint 5; no other lines.

Stage III.—Head rounded, the vertex just within joint 3, pale reddish over the lobes and sides, luteous on the face, shining, very small in proportion to the body; width, 0.6^{mm}. Body robust, slightly thickened at joint 5, more so at joint 12; feet normal; pale green; a straight dorsal and a subdorsal white line and traces of a broken lateral one; subventral region slightly pale, without defined line; tubercles small, black; a large, vinous, somewhat elevated blotch on tubercles i and iv on joint 5 and on tubercle i on joint 12, more diffusely about the spiracle on joints 11–12; anal feet reddish; cervical shield small, infuscated, cut by three white lines; anal plate blackish; thoracic feet blackish, abdominal ones greenish.

Stage IV.—Head rounded, rather quadrate, not notched, the clypeus high, vertex even with joint 2; pale red, paler on the clypeus, ocelli and antennæ dark; width 1.0^{mm}. Body robust, thickened at joints 5 and 12, feet equal; blackish olivaceous, dorsal and subdorsal lines straight, yellowish white, edged with vinous dottings; traces of a lateral line; subventral region paler below the spiracles, especially after joint 5; large blackish-red blotches at tubercles i and iv on joint 5 and on joint 12 and tubercle i and stigmatally on joints 11–12; white dotting in the ground color most conspicuous stigmatally; thoracic feet black, abdominal ones pale, anal pair reddish.

Stage V.—Head quadrate, rounded, slightly bilobed, shining light red-brown, the clypeus high; ocelli and setæ black; width, 1.6^{mm}. Body thickened at joints 5 and 12, feet equal, normal, the abdominal ones pale, slightly infuscated, the thoracic ones black-ringed; dark gray to black, strigose-dotted with white; dorsal line narrow, subdorsal broader, straight, even, yellowish white, centered with reddish mottlings, cutting the sooty-black cervical shield, but not the anal plate; a quadrate black patch between the lines on joint 5, a small angular one next the subdorsal line on all the other segments, large on joint 12 and shaded across; a narrow white-dotted lateral line, scarcely different from the dots of the ground color; subventral band straight, yellow-white, broad, broken at joint 5, reddish-filled around the spiracles, black spots at tubercles iii with a distinct white dot below; subventral region of thorax blackish, of abdomen paler, white-dotted.

Stage VI.—Head rounded, quadrate, about as high as wide, slightly bilobed, the vertex level with joint 2; clypeus high and large; red-brown, darker reticulate, mouth-parts concolorous, ocelli black; width 2.1 to 2.4^{mm}. Body robust, cylindrical, tapering from joint 5 to joint 2, the head small; joint 5 slightly, joint 12 distinctly, enlarged and abruptly tapered to joint 13; black, strigose-dotted with white; cervical shield deep black, white-dotted, cut by three white lines; anal plate similar, small, cut by the dorsal line only; dorsal line narrow, black-dotted and broken, yellowish white, reddish on the centers of the segments; subdorsal line broader, straight, yellow-white, reddish centered on the segments, with a median row of gray dots, but not incised on the margins; a row of segmental black triangles above it, free of white dots, largest on joint 5, the one on joint 12 now scarcely larger than that on joint 11; upper half of the lateral area grayer, with many white dots, lower half blacker, with few dots on joints 5 to 13, separated by a row of brighter dots representing the lateral line; on joints 2 to 5 this distinction is weakly developed; spiracles in a blacker shade with a white dot above tubercle iv; substigmatal band broad, even, undulate, weak and broadly gray, centered on joints 2 to 5, fading out at joint 5, sharply reappearing at joint 5 posteriorly, then pale yellow, centered with blackish mottlings at the centers of the segments and red above these; subventral region black-shaded, strongly so on joints 2 to 5, weakly on the abdomen, white-dotted, paling to the venter; thoracic feet dark brown, the abdominal ones pale brown, shining; a single cylindrical, round-tipped neck gland reaching to the end of the labial palpi; crochets of abdominal feet in a single row, dark; tubercle iv slightly above middle of spiracle on joint 7. [Harrison G. Dyar.]

ORIGIN AND DISTRIBUTION.

This is a Lower Austral form and probably of tropical origin. In the National Museum are specimens from Cocoanut Grove, Crescent City, and Orlando, Fla. The species is also recorded from Tallahassee, and reported from St. Augustine and the region about the Manatee River in Florida. From Texas we have specimens from Bosque County (Belfrage) and Dallas, and there are specimens collected at Pernambuco, Benito Province, Brazil, by Mr. Albert Koebele. Dr. J. B. Smith records the insect from Georgia and Central and South America, and Grote records it from California. This indicates a range extending from Brazil to Mexico, Central America, and the Antilles, and from Florida westward through the Gulf region and Texas to California.

LITERATURE AND HISTORY.

Considering the fact that this species is really common in the South and that it feeds gregariously and voraciously, it is somewhat remarkable that it has not hitherto attracted attention by its depredations. The moth was described by Pierre Cramer in 1782.[1] [a] Its natural food plants were known to Smith and Abbot, who wrote of it in their classic work published in 1797.[2] The illustration accompanying that work, though over-colored as usual, depicts a perfectly recognizable moth of this species but a too-brilliant and light-colored larva. Light and dark forms of the moth are figured. The species is mentioned as *Phalæna phytolaccæ* and is compared with the related *Prodenia commelinæ* and *Laphygma frugiperda*, which form the subject of the two plates and pages immediately preceding the account of *phytolaccæ*.

As Smith and Abbot's work is not accessible to many, the following copy of their account of this insect is republished:

PHALÆNA PHYTOLACCÆ. Poke-weed moth.

Phytolacca decandra. Linn. Virginian poke-weed.

Ph. *Noctua* spirilinguis cristata, alis deflexis: primoribus fusco striatis puncto obscuro margine postico nigro maculato; anteriori punctato.

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[a] Numbers in superior type refer to corresponding numerals in the appended bibliographical list (p. 70).

Feeds on the Poke, Careless, &c. It went into the ground July the 5th, and came out the 16th. I once met this caterpillar in such abundance, that among a great quantity of Poke plants there was scarcely a single leaf untouched; most of these caterpillars, however, were fly-blown by a kind of *Ichneumon*. The moth is rare.

This is allied to our *Ph. frugiperda* and *Commelinæ*. Between the under wings of all these there is the greatest affinity. Their *pupæ* too are of a similar bright red color, and their smooth-striped caterpillars have much resemblance to each other.

RECENT INJURIES AND BIOLOGIC NOTES.

On May 14, 1907, this species was observed on the leaves of tomato in the truck garden of Mr. C. M. Berry, at Orlando, Fla., where it was eating holes in the leaves. Numbers of plants, here and there, were infested and in most cases the entire plant was injured. The same larva was observed on pokeweed (*Phytolacca decandra*), and afterwards on spiny amaranth (*Amaranthus spinosus*). By May 20 the larvæ were scattering and had grown rapidly, some being an inch long. While young, these larvæ feed on the underside of the leaf, but with larger growth some were noticed feeding on the upper surface as well.

May 24 an egg-mass was found on a leaf of the spiny amaranth, laid in two sections on the under surface, one on each side of the midrib. One mass had hatched at this time and the larvæ were beginning to eat pinlike holes through the leaf.

On July 3 a field of Irish potatoes was found to be very badly infested by these larvæ. They were now nearly full-grown and had stripped the potato vines, many being observed crawling away from the field in all directions. On one side they infested a garden at least 600 feet away, and were feeding upon eggplant, pepper, okra, and castor-oil plants.

Some interesting notes were made on the abundance of this species in this potato field. On a single young plant of Amaranthus, 41 larvæ were counted, and as many as 314 on a plant measuring 6 feet in height. A careful estimate of the larvæ on 10 plants of careless weed, not over 6 feet in height, gave a total of 1,300 individuals. (See fig. 9.)

To illustrate the voracity of these larvæ, where any potatoes were exposed, they were soon covered by the larvæ and the entire contents eaten out so that they were rendered worthless in about ten minutes. About this same date, July 3, the larvæ were reported making quick work of amaranth; whenever a branch became broken from any cause, larvæ entered at the break and excavated tunnels several inches in length. Pokeweed was entirely stripped of leaves, the stalks and the shoots being eaten off at the outer end. Potatoes dug at this time were frequently found full of holes, the work of these larvæ. The following day, July 4, the amaranth was almost completely denuded, illustrating the rapid work of this species when in large numbers (see figs. 10, 11). By July 8 the larvæ had almost completed their work in the field, after having eaten everything clean. Many were full grown and had commenced to enter the ground. July 9 the potato field was stripped, the vines were dead and dry, and the larvæ had almost disappeared. The ground was full of pupæ, none of them at a greater depth than 4 inches, and in many cases only 2 inches. Upon digging into the hills, it was found that they did not average more than four good-sized potatoes to the hill, and in many cases these had been rendered useless by the inroads of the larvæ. (This crop averaged small because of late planting.)

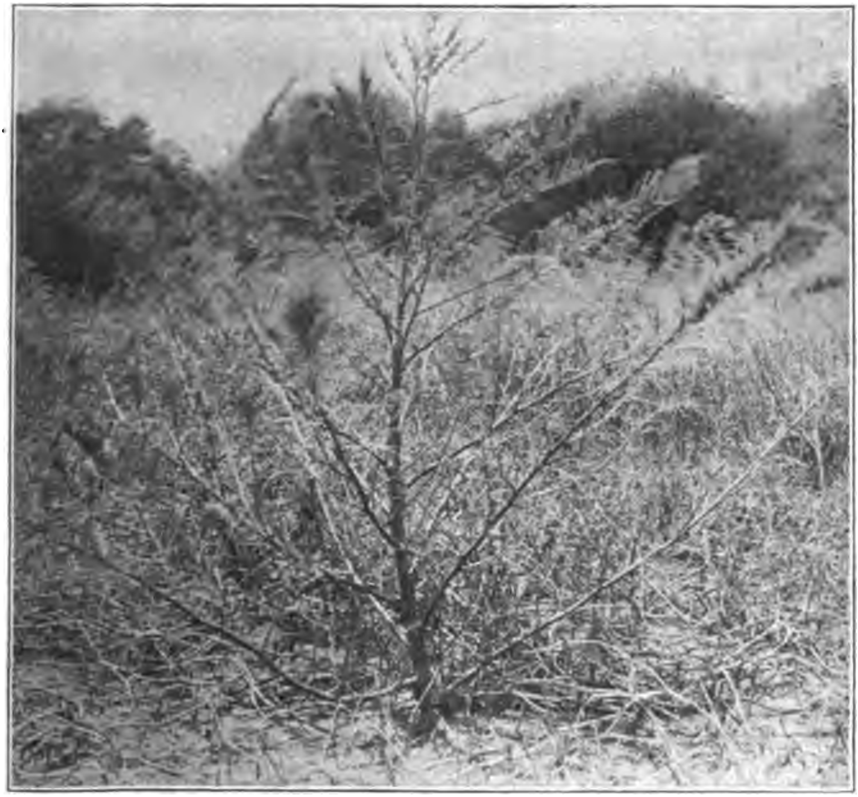

FIG. 9.—The semitropical army worm (*Prodenia eridania*): Work of larvæ on "careless weed" in potato field; 311 larvæ were on this plant when photographed. (Original.)

Many larvæ were found feeding on sweet potatoes at Mr. John M. Cheney's place at this time, most of them still in young stages. A few fully matured larvæ also were found, showing the overlapping of the two generations; in fact, observations conducted both in the field and at the insectary at Washington, D. C., show that this species is undoubtedly a continuous breeder, as in the case of the variegated cutworm (*Peridroma margaritosa* Haw.), the larvæ being present in the field throughout the long summer season of the South.

July 30, by request of the county commissioner, Mr. H. H. Dickson, the junior author went to the County Home and found a sweet-potato patch badly infested, thousands of larvæ present, and the leaves turning brown and drying out. Superintendent Harris stated that an earlier brood did great damage to cowpeas, but this could not be verified by specimens. In the sweet-potato field the larvæ started on the south side and, after stripping the first four or five rows, moved over to the next rows and eventually infested the entire field. A Mr. Porter, near the County Home, reported 5 acres stripped in three days after the larvæ were noticed at work, these having started at one side of the field and swept it clean. The larvæ of a third generation were observed at Mr. Cheney's place at this time; most of them, however, had already gone into the earth to transform.

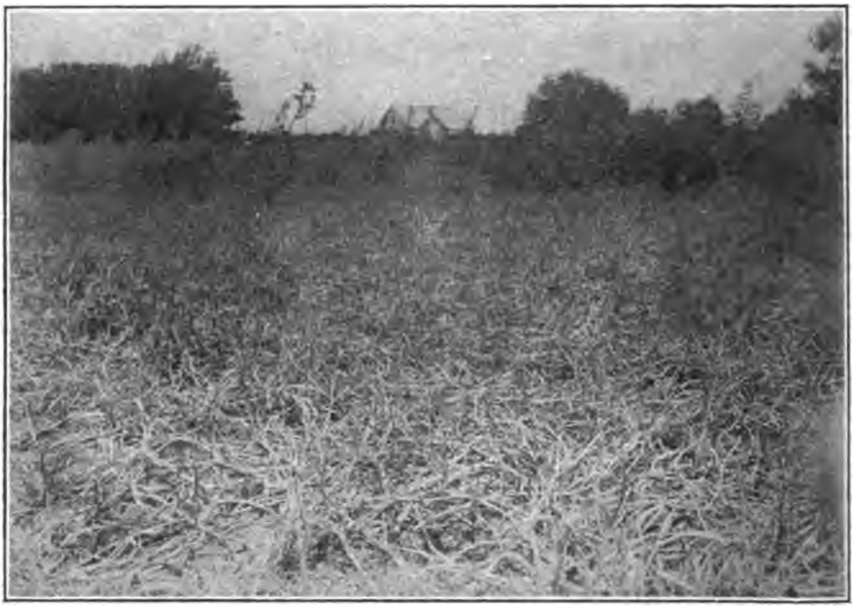

FIG. 10.—The semitropical army worm (*Prodenia eridania*): Field of late Irish potatoes showing vines entirely stripped by larvæ; Orlando, Fla., July 6, 1907. (Original.)

August 3, adults that had pupated about July 25 began to emerge. Thus the pupal period occupied about nine days. At this time a number of young larvæ were noted feeding upon amaranth, wild Solanum, and castor-oil plants. When disturbed they dropped and hung by threads.

By the first of September Mr. Cheney's patch of sweet potatoes was entirely free from this insect, evidently owing largely to parasites and to the spraying with arsenate of lead.

August 30, 1907, Mr. Wm. Donnell, St. Augustine, Fla., reported that a cutworm, which he identified as this species, had been very destructive in that region, being especially abundant on beets, and later affecting cabbage, carrots (by eating the tops), and some other plants, its operations being most noticeable at night.

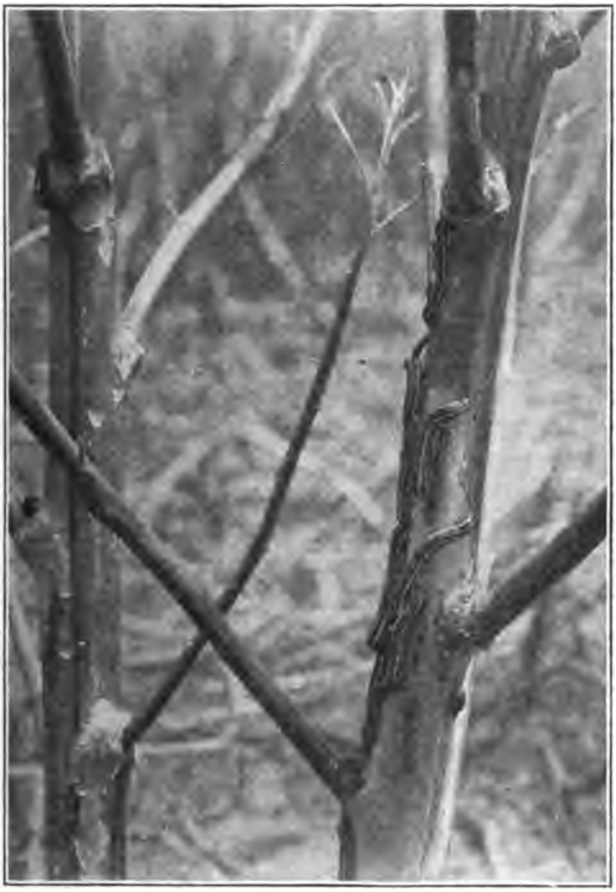

Fig. 11.—The semitropical army worm (*Prodenia eridania*): Larvæ eating bark of "careless weed;" also nymph of *Podisus maculiventris*, predaceous on the larvæ. (Original.)

Mr. E. L. Worsham, while employed by this Bureau, noticed this species on the west coast, near the Manatee River, in Florida, and reported it working quite extensively in that region in August.

On November 23, 1907, an egg-mass was found on pokeweed at Dade City, Fla., and December 2 another was observed, from which the larvæ hatched December 4. These molted between December 10 and 13, while being transported to Orlando, but soon died, as frost killed off the food plants.

July 25, 1908, Mr. H. H. Dickson asked for a remedy to apply against the larvæ on sweet potatoes at the Orlando Truck Farm.

Egg-masses received May 24, 1907, hatched at that time and the larvæ entered the earth in the rearing cage June 19. In dry sand the pupæ were found at a considerable depth, but in moist sand they were found barely under the surface.

July 8 larvæ in the rearing-cage were almost full grown. Larvæ hatching from egg-masses, and others a few days old, were also found in abundance on sweet-potato plants. As soon as hatched they separate, feeding on the leaf on which the egg-mass was laid, perforating the underside full of minute holes, and leaving only the upper epidermis, which turns brown. On growing larger they separate, as in the case of most caterpillars, except those of peculiarly gregarious habit, and soon become widely scattered. Even when abundant it is common to see eight or a dozen on the underside of a single leaf, and frequently as many as an hundred. Occasionally a nearly full-grown larva feeds on the upper side of a leaf. In many cases large larvæ were found hiding during the day at the bottom of furrows.

June 15, 1908, the larvæ of this insect were found to be very abundant at Orlando, Fla., in one part of the town feeding on pokeweed, and in another on amaranth.

EARLY RECORDS.

Among the records of the Bureau of Entomology is one of May 22, 1887, when larvæ and pupæ were received from Mr. E. A. Schwarz with report that the species was very injurious to the eggplant at Cocoanut Grove, Fla.

In September, 1905, Mr. F. C. Pratt sent to the Bureau a large colony of the larvæ found feeding on pokeweed at Dallas, Tex., the moths from which began to issue September 26.

LIFE-CYCLE PERIODS AND GENERATIONS.

Larvæ mailed from Orlando, Fla., July 3, arrived at Washington, D. C., July 5 and began to enter the earth for pupation the following day. On the 16th two had transformed to pupæ, on the day following three more, and the remainder transformed within a week. This experiment shows a pupal period of about 9 days, allowing 1 day for the larvæ in the earth before pupating. The weather was quite hot. In a cooler temperature in August the pupal period required 11 to 13 days.

The moths hatched from different lots were separated and the egg-period observed. In one case this lasted from August 8 to 12, or

4 days, and in another case from July 18 to 22, or 4 days. In the first instance the temperature averaged between 76° and 80° F. and in the second from 80° to 88° F. Evidently this is the maximum period.

As regards the duration of the entire life cycle, it was noticed that eggs deposited July 3 produced caterpillars on the 9th, or in 6 days. These penetrated the earth, being full-grown, on the 26th, making the entire life period of the larvæ 17 days. They began to issue as moths August 5. This gives a total period for the life cycle of 31 days for extremely hot weather. In an ordinary outdoor summer temperature the period would be about 35 days, or 5 weeks.

Our rearing records are not quite as accurate as could be desired, owing to unfortunate conditions at the insectary and to three changes in the office force during the time when the insect was under observation. There were, however, positively four generations here, and about the same number was observed at Orlando. There is also the possibility of an earlier fifth generation in nature. The exact periods for the appearance of these should be recorded in the field.

NATURAL ENEMIES.

The unusual abundance of this species at Orlando, Fla., during the season of 1907 afforded a most excellent opportunity for the study of its insect natural enemies. These came under observation as early as May and were still abroad as late as August, appearing to increase somewhat as the season advanced.

PARASITES.

The parasitic species observed were seven in number; the predaceous enemies, six.

Ophion tityri Pack. (?)—Issued July 17–August 1.

Limnerium sp.—Issued May 25–30.

Meteorus sp.—Issued July 11–August 2.

Chelonus sp.—Issued July 6, 1908.

Spilochalcis spp.—The Meteorus was attacked by two species of secondary parasites of the family Chalcididæ. These issued August 2 from the peculiar brown cocoons of the Meteorus.

Winthemia quadripustulata Fab., a moderate-sized tachina fly, is also a parasite on the larva of this species. Adults issued August 8 but did not appear abundant. Of a lot of larvæ taken at random from different portions of a field, upward of 50 per cent bore tachina-fly eggs. Evidently a large percentage fail to hatch.[a]

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[a] A small fly was also observed feeding on the pupæ. It is *Aphiochæta nigriceps* Loew, one of the Phoridæ, which comprises species of scavenging habits and not parasitic.

PREDACEOUS ENEMIES.

Calosoma sayi Dej.—The larvæ of the carabid beetle *Calosoma sayi* were observed in considerable numbers and were reared to adults. They were first noticed July 6, when they were quite abundant in the furrows between rows of sweet potato. They were found concealed by the vines, feeding on the larvæ of the Prodenia, and after sucking out the juices of one larva they immediately attacked another. The adults issued in our rearing cages August 11.

Polistes annularis L.—The large brown wasp *Polistes annularis* was observed July 2, flying quite commonly in sweet-potato fields. One was watched which alighted on a leaf and began searching for prey, after the custom of such wasps. The search was continued from plant to plant and from leaf to leaf until a Prodenia larva was located, when it was at once seized behind the head and chewed into a shapeless mass. Other wasps of this species were also seen on fence posts dragging Prodenia larvæ about with them.

It is interesting to note that Mr. F. F. Crevecoeur, Onaga, Kans., reports having seen this wasp being carried away by the asilid robber-fly, *Deromyia ternata* Loew.

Stiretrus anchorago Fab., var. *diana* Fab.—The blue-and-red and the uniformly blue forms of the soldier-bug *Stiretrus anchorago*, which are common in Florida, were observed in numbers attacking the Prodenia larvæ in July.

Podisus maculiventris Say.—During July the spined soldier-bug was seen preying upon the Prodenia larvæ. (See fig. 11.) In one instance 18 nymphs were counted on a single amaranth plant infested by the cutworm. The length of the life cycle of this species from hatching (not from egg-laying) was determined to be 16 days in hot July weather.

Apateticus (*Eupodisus*) *mucronatus* Uhl.—July 17, and again in December, 1907, this pentatomid bug was observed preying on the larva of this species of Prodenia at Orlando, Fla. It is considered a rare species and this is probably the first observation which has been made on its habits.

Owing to the obscurity of the host insect in the past, no records can be found of any of these parasites or of other natural enemies which affect it, but in Smith and Abbot's work mention is made of a species of "Ichneumon" which attacks the larva (see p. 58).

Pontia rapæ L.—July 22, 1907, the young larvæ of the imported cabbage worm, which had hatched out on cabbage used as food for *Prodenia eridania* Cram. in our rearing cages at Washington, were observed feeding on the eggs of the latter.[a] The cabbage worms were between one-quarter and three-eighths of an inch in length at this time.

A FUNGOUS DISEASE.

Empusa sp.—September 8, 1907, a few Prodenia caterpillars, which were found dying of a fungous disease in our rearing cages, were referred to the Bureau of Plant Industry for identification of the fungus. Mrs. F. W. Patterson stated that it was a species of Empusa.

METHODS OF CONTROL.

The arsenical poisons are effective against this army worm under ordinary conditions. Experiments performed at Orlando, Fla., however, brought out the fact that Paris green, on account of the frequent rains which occur at the height of the principal outbreaks in the infested regions of Florida, such as Orlando, is almost ineffective and it is therefore necessary to use arsenate of lead. Owing to the greater adhesiveness of the latter it remains on the plants when the former is washed off.

Paris green, arsenate of lead, and a special preparation which may be called adhesive copper arsenite, were tested, the last by request of its inventor. It was used in experiments Nos. 8, 10, and 11. A barrel sprayer, fitted with Vermorel nozzle, was used for a number of these experiments, but for most of them a knapsack sprayer of fine quality was employed. Sweet potatoes were sprayed in every case except in experiment No. 5, where collards were also sprayed, and the work was usually begun between 8 and 10 a. m. in bright sunlight. Spraying experiments commenced July 12 and were continued until August 7.

Experiment No. 1.—July 12, infested plants were sprayed with a solution of Paris green, 5 ounces, and fresh air-slaked lime, 5 ounces, in 50 gallons of water. The spraying was done in the morning and rain fell before noon. The next day when the field was examined the larvæ were found uninjured and practically no poison remained on the leaves. The experiment was therefore a failure.

Experiment No. 2.—July 12, Paris green, 8 ounces, and freshly slaked lime, 1 pound to 50 gallons of water, were sprayed the same day and with the same results.

Experiment No. 3.—July 17, Paris green was sprayed as in No. 2. Again rain fell hard and steadily before noon, with the same results as in experiments 1 and 2.

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[a] This would seem to furnish at least one reason why this important insect has been able to supplant its American cousins such as *Pontia napi* L., *P. protodice* Bdv. & Lec., and *P. monuste* L., all of which feed on crucifers and are called cabbage butterflies or "worms."

Experiment No. 4.—Arsenate of lead, 2 pounds to 50 gallons of water, was used. Rain fell as before, resulting in partial failure of the experiment, the poison being washed off before it had time to dry thoroughly.

Experiment No. 5.—July 20, arsenate of lead was used as in experiment No. 4. Collards were also sprayed. Rain did not ensue for at least six hours, giving the spray time to dry on well in the warm sun. The following day it rained hard for several hours, but the next day the spray was found to be as thick on the sweet potatoes as when first put on, in spite of two partially rainy days. The poison was nearly as thick on the collards. An examination of the infested plants two days after spraying showed that only 25 per cent of the caterpillars were killed, but July 23, a day later, few large larvæ remained on the plants, showing that as soon as they have eaten sufficient poison they are killed.

July 29, when the rows sprayed with arsenate of lead were again examined, they were found in much better condition than the check or unsprayed rows, few larvæ being seen feeding, while dead ones were plentiful.

Experiments Nos. 6 and 7.—July 20, a sweet-potato patch was sprayed with Paris green, 8 ounces to 50 gallons of water. As in the case of experiment 5, no rain fell for about six hours; therefore the poison dried on well, as previously. The following day it rained hard for several hours, with the result that by July 22 the poison was all washed off and only a few dead larvæ were found. All of the Paris green experiments were failures, since the rain washed the poison off either before it could dry or after it was well dried on the plant.

Experiment No. 8.—July 23, the adhesive copper arsenite (combined with dextrine and glucose) was used at the rate of 1 pound to 100 gallons of water and applied as in previous experiments. The following day no results were observed, but the foliage was not burned. At the end of a week no good was accomplished and the experiment was pronounced a failure.

Experiment No. 9.—July 25, plants were again sprayed with arsenate of lead, 2 pounds to 50 gallons of water, the conditions being as in experiment No. 5. Rain at 12.45 p. m. washed off the poison, consequently the spraying was a failure.

Experiment No. 10.—July 25, plants were sprayed with the copper arsenite mixture; 10 ounces to 50 gallons of water were applied as in experiment No. 8, an equal quantity of lime having been added. The spray did not show well on the foliage and was invisible when dry. It does not remain in suspension as well as Paris green and much residue remains in the tank. July 28, a few dead larvæ were found on the vines and only a few live ones, but the same conditions were observed on the check rows. The experiment was an absolute failure.

Experiment No. 11.—July 29, plants were sprayed with copper arsenite mixture at the rate of 15 ounces to 50 gallons of water. In this case 1½ ounces of copper arsenite and 1 quart of thick lime were used with 5 gallons of water. Two days later the spray showed better than in experiment No. 10 because of an abundance of lime and was very finely and evenly applied to the leaves. Four larvæ were dead on a few plants examined against 32 living Prodenia and 3 living sweet-potato sphinx-moth larvæ (*Phlegethontius convolvuli* L.).

August 6, this spray still remained on the foliage, seeming to adhere well, but the experiment was a failure in killing larvæ.

Experiment No. 12.—July 29, plants were sprayed with arsenate of lead, 3 pounds to 50 gallons of water, applied as in previous experiments with lead arsenate. There was no rain for 24 hours. On a few plants examined three days later 41 dead larvæ were found and 49 living, an observed death rate of less than 50 per cent. It should be pointed out at this time, however, that it is difficult to find dead larvæ, as they sometimes dry up or crawl away.

August 2, the vines were almost free from larvæ. The experiment was pronounced very successful.

Experiment No. 13.—July 30, arsenate of lead, 2 pounds to 50 gallons of water, was used without ensuing rain. In some rows examined August 1 about 20 per cent of the larvæ were dead; in others 48 per cent, 54 per cent, and 61 per cent were killed in two days. August 5, these rows appeared entirely free from larvæ unless closely inspected, when only 5 or 6 could be found to a row. These might have crawled from unsprayed weeds or other plants.

Experiment No. 14.—July 30, arsenate of lead, 3 pounds to 50 gallons of water, was used. Three days later 84 per cent of the larvæ under observation were destroyed, the rows being quite clean. In both of these experiments, 13 and 14, many dead larvæ were found in rows *not* sprayed, as many as five rows away from the sprayed ones.

Experiment No. 15.—August 7, arsenate of lead, 2 pounds to 50 gallons of water, was sprayed by a laborer, under supervision. It rained at 1 p. m., but the spray remained on the leaves in large amounts and, for having been applied by an inexperienced hand, was well distributed. In this experiment, for some reason, the first four rows sprayed at one filling of the tank produced quite a number of burned leaves. This was attributed to a possible mistake in weighing out the chemicals. It did not, however, permanently injure the plants.

Caterpillars in the last 4 experiments, supposedly of the third generation, were very small, not over one-fourth or one-third of an inch in length. As a consequence they were quickly killed, large numbers of them being found dead soon after spraying. Forty-three dead larvæ were found in a furrow beside one plant which contained 29 dead larvæ. In another place 112 dead larvæ were counted in 3 feet of furrow.

RÉSUMÉ OF EXPERIMENTS, AND CONCLUSIONS.

Experiments 1, 2, 3, 6, and 7, in which Paris green was used at the rate of 5 to 8 ounces in 6 gallons of water, were failures because in each case the rain which followed the application washed off the poison.

Experiments 4 and 9, in which arsenate of lead was used at the rate of 2 pounds to 50 gallons of water, were also failures for the same reason.

Experiments 8, 10, and 11, in which copper arsenite was used at a rate of from 10 ounces to 1 pound in 50 gallons of water, failed, not because of burning the foliage, as was feared, but because the insects were not killed.

Experiments 5, 12, 13, 14, and 15, in which arsenate of lead was the insecticide employed at the rate of 2 to 3 pounds in 50 gallons of water, were successful in each case.

The results of this series of fifteen experiments show conclusively the superiority of a spray of arsenate of lead to one of Paris green when applied under suitable conditions. It is in every way more effective and more satisfactory than the latter, as Paris green is so likely to be washed away by the frequent rains of the wet season of Florida. These remarks apply practically to all cutworms, caterpillars, and other larvæ which devour truck and related crops in central Florida or similar regions.

ADHESIVE COPPER ARSENITE MIXTURE.

The preparation of copper arsenite used in the experiments that have just been reported was stated by its inventor to be free from soluble arsenious acid and to possess the adhesive properties found in no other adhesive insecticide. It was stated to be composed of 36 per cent dextrin and 4 per cent gum and was prepared to be used in conjunction with lime in the proportion of 1 part by weight to from 4 to 6 parts of lime—either dry or in solution, according to the foliage to be tested. The inventor also expressed his confidence that this insecticide would prove a most economical one for general garden and other use, as the loss by wind and rain would be reduced at least 50 per cent and the first cost of the article would be about half that of Paris green or arsenate of lead.

Samples of this mixture were submitted to Mr. J. K. Haywood, Chief of the Miscellaneous Laboratory, Bureau of Chemistry, who furnished the following analysis, August 7, 1907:

Analysis of 4551 Misc.

	Per cent.
Moisture	4.85
Total arsenious oxid	40.42
Total copper oxid	24.87
Gum and dextrin (approximate)	20.00
Acetic acid and other undetermined	9.86
Total	100.00
Soluble arsenious oxid	11.36

(10 day water ext. method.)

From the above analysis the sample evidently consists of about 20 per cent gum and dextrin and 80 per cent Paris green. The amount of soluble arsenic is very high and would undoubtedly give rise to serious trouble.

SUMMARY.

The semitropical army worm is a smooth or hairless noctuid caterpillar, *Prodenia eridania* Cram. It feeds normally on weeds, such as the pokeweed and spiny amaranth or "careless weed" of the South, and is confined to semitropical America as a pest. When it becomes unduly abundant it attacks the foliage and, in some cases, the stems and fruits of all forms of garden truck growing in its habitat, the list of known food plants including tomato, potato, sweet potato, eggplant, pepper, okra, collards, and cowpeas. In its habits it is similar to the cutworms, having also the climbing habit, and when extremely abundant it migrates in armies like the common army worm, whence the name.

Experiments show that the egg period may be passed in a minimum of 4 days, the larval period in 17 days, and that the entire life cycle, in an outdoor summer temperature, would be about 35 days or 5 weeks; also, that there are four generations and possibly five produced in a year, the insect breeding practically continuously during the warm season. In ordinary years the species is largely controlled by natural enemies, of which seven are parasitic and six predaceous.

A series of fifteen experiments was conducted against this species in Florida during 1907, which shows conclusively that a spray of arsenate of lead is the best remedy, being much superior to Paris green when applied under local conditions. It is in every way more effective, chiefly because less likely to be washed away by the frequent rains of the wet season in that region. It is best applied at the rate of 2 or 3 pounds in 50 gallons of water, and applications must be renewed when the insects again become numerous, as the latter are apt to spread from unsprayed plants.

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In Smith's catalogue of Noctuidæ,[7] fifteen references are given to this species, but as only a few of these are of interest in connection with the present account, the reader is referred to that list. The more important references are listed above.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 66, Part VI.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE HOP FLEA-BEETLE.

BY

F. H. CHITTENDEN, Sc. D.,
In Charge of Truck Crop and Special Insect Investigations.

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(*Psylliodes punctulata* Melsh.)

By F. H. Chittenden, Sc. D.,
In Charge of Truck Crop and Special Insect Investigations.

INTRODUCTORY.

A minute, metallic blackish flea-beetle, *Psylliodes punctulata* Melsh., known by different local names, has been reported in recent years as doing very extensive injury to the hop plant and considerable injury to sugar beet. Since 1904 it has been reported in numbers on sugar beets grown in several localities in Idaho, Utah, and Colorado. In the Northwest, and particularly in British Columbia, it does serious damage in hopyards, and has been especially destructive since 1903. During the past three years, indeed, this species has become unusually abundant, with the result that in the Chilliwack and Agassiz Valley hop-growing regions of British Columbia it has accomplished damage which has been estimated by Mr. H. J. Quayle as about 80 per cent of the crop. Mr. Theo. Eder informs the writer that this means a cash loss of not less than $125,000 in that district. The species during that period has been the subject of considerable correspondence between this Department and persons practically interested in the growing of hops in the affected region.

The insect has received the name of rhubarb flea-beetle, from its common occurrence, especially in the East, on rhubarb. In the West it is called the hop flea-beetle, or " hop flea," or simply " flea," and in literature it has received mention as the punctulated and the small-punctured flea-beetle.

While the species is not known to be of the highest importance as a sugar-beet pest, the probabilities are that it may become so, and at the present time it is probably the most important hop pest in the entire world. The incorporation of some new matter, gained from conversation with Mr. Theo. Eder and by correspondence with Mr. H. J.

Quayle, has added much to the value of the present paper. Although the species is much more serious as a pest in British Columbia than in the United States, it is likely to become important throughout the Pacific coast region where hops are grown. Mr. Eder represents the E. Clemens Horst Company, which owns extensive hop-yards in British Columbia, and has already expended considerable sums in investigation and experiments. The hop flea-beetle is now abundant practically on the border line between British Columbia and the State of Washington, and threatens our own industries. It is, therefore, advisable that everything possible concerning it should be made public before its appearance in the spring, although there are several points in its life history still to be worked up.

DESCRIPTIVE.

The hop flea-beetle (fig. 12) is a member of the tribe Halticini. family Chrysomelidæ, and resembles other flea-beetles in its strongly developed hind thighs. It is of oval form, with a greenish tinge, brassy blackish, and punctulate or finely punctured, whence its specific name. The femora, tarsi, and basal joints of the antennæ are pale yellowish. The punctulations of the thorax are particularly fine and appear as if made with the point of a very fine needle. The punctures of the elytral striæ are closely placed, almost crenate. The beetle is only about one-tenth of an inch (2^{mm}) in length and less than 1^{mm} in width. The male is particularly distinctive, having the first joint of the anterior tarsi broadly dilated and the last

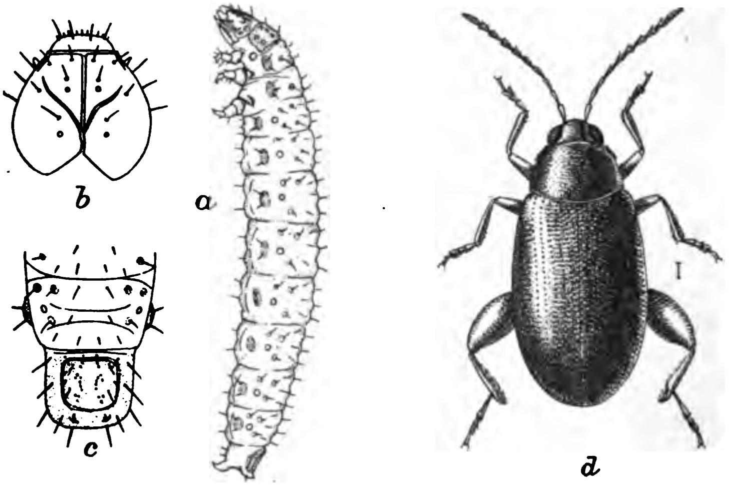

Fig. 12.—The hop flea-beetle (*Psylliodes punctulata*) : *a*, Larva ; *b*, lower surface of head of same ; *c*, upper surface of anal segments of same ; *d*, beetle. *a*, *d*, Much enlarged ; *b*, *c*, more enlarged. (*a–c*, After Carpenter ; *d*, original.)

ventral segment sinuate each side, while the middle of the disk near the apex has a semioval depression.[a]

The species was first described in 1847.[1] [b]

DISTRIBUTION.

The hop flea-beetle is a native American species, quite distinct from any species found on hops in England or on the Continent.

The collection of the U. S. National Museum and the published records and specimens before the writer show the species to be generally distributed in the northern United States and southern Canada, from the Atlantic to the Pacific. It does not appear to occur south of Nebraska. The list of known localities follows: Cambridge, Mass.; Dundee, Ithaca, Long Island, Staten Island, and New York, N. Y.; New Jersey, generally distributed (Smith); Pittsburg, Pa.; Marshall Hall and Cabin John, Md.; Marquette, Detroit, Grand Ledge, and Byron, Mich.; University, N. Dak.; Lincoln and Omaha, Nebr.; Fairfield, Wyo.; Denver, Longmont, Grand Junction, Delta, Montrose, Paonia, and Ft. Collins, Colo.; Logan, Garland, Lehi, Salt Lake, and Park City, Utah; Elko, Nev.; Blackfoot, Idaho; San Francisco, Martinez, Monterey, Huntington Beach, Pasadena, and Chico, Cal.; Tenino, Wash.; Astoria and Marion, Oreg.; Agassiz, Sardis, and Vancouver, British Columbia; Northwest Territory; Manitoba; and "Assiniboia" (now Saskatchewan).

RECENT INJURIES.

September 16, 1903, the late Dr. James Fletcher first reported this species injuring hops in British Columbia.

During 1906 Mr. Theo. Eder wrote from San Francisco, Cal., under date of April 9, that hop growers were troubled considerably in some sections by "hop fleas," or flea-beetles. May 29, specimens were received from Perkins, near Sacramento, Cal., which proved to be the species under consideration. August 13, Mr. Hugh F. Fox, New York, N. Y., sent specimens and transmitted a report from Mr. Geo. Heggie, manager of a large hopyard, the Stepney ranch, owned by Sir Arthur Stepney, at Enderby, B. C., where this pest was very injurious. Mr. Heggie wrote as follows:

> We have been sorely troubled this year in our hopyard with the "hop flea-beetle," which attacks the young vine and leaf as soon as they appear above the ground, and eats out large holes in the leaf, resulting in the plant being

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[a] In the very closely related *Ps. convexior* Lec. the last ventral segment of the male is convex and not impressed. The latter species is, moreover, larger, broader, and more convex, and the elytral striæ are not impressed.

[b] The numbers in superior type refer to corresponding numbers in the appended bibliography, p. 91.

impoverished in vitality and the growth thereby seriously retarded. We were troubled with them last year [1905], but not to the same extent, and had them till after hop picking. In the middle of July they were so numerous that the ground was fairly alive with them. They go into the ground in the evening and come out again in the morning, and there has been no spray found to have any effect without killing the plant.

Substantially the same form of injury was reported during the same year at Agassiz, B. C., by Mr. John Wilson in a letter to Doctor Fletcher. Writing September 7, 1906, Doctor Fletcher stated that this species had been enormously destructive in British Columbia, one correspondent reporting the loss of many thousands of dollars. He estimated his crop as possibly 70 bales, whereas he should have had 250.

Writing of this species, January 30, 1907, Dr. E. D. Ball, while working in cooperation with the writer, stated that it was by far the most injurious species on sugar beet in Utah. It was found everywhere and was apparently the most common species in early spring. It was observed hibernating around the edges of fields, in patches of dead mustard, along ditch banks, and in similar places. Where ditches were covered with patches of roses these seemed to furnish a favorite retreat. These clumps grew to a height of 2 or 3 feet and were very dense, and from them one could see the injury to the beets radiating in every direction, the affected area growing wider and wider as time went on. In early spring this species fed on almost anything that came to hand, but its injury to beets was practically all done at the time the plants were first appearing through the ground or within a few days thereafter. Cases were observed where the rows of young plants could be seen the entire length of the field one day, and two days later scarcely a beet plant could be found, the beetles having eaten the tender stem, causing the tops to fall off and the beets to die. Frequently they attacked beets just as the latter were pushing through the ground. Hundreds of acres had been destroyed in this way, injury varying greatly in different years and in different localities.

Great damage was done near Logan, Utah, where the hedge mustard was overrunning the fields. At Lewiston, Utah, at the northern end of the same valley, injury was also severe, although there was little of the common black mustard.

The destruction of a crop by this species does not necessarily entail a complete loss, as the growers replant. The late plants, however, are not, as a rule, as good as the earlier ones, and the weeds get such a start that the land is hard to cultivate. After the beets had reached a leaf diameter of 3 or 4 inches no material injury was noticed, although the beetles continued to appear in the fields throughout the season. Beetles were observed July 20, 1906, at Cache Junction, Utah, enormously abundant on a form of hedge mustard along the railroad tracks, feeding on the half-grown seeds. Single plants were seen on which a double handful of beetles could be taken at one stroke of the net.

In a letter dated July 20, 1908, the E. Clemens Horst Company, Perkins, Cal., wrote of extensive injury by this species, and as this letter contains much of interest it is transcribed herewith. The writer is greatly indebted to the same company for the excellent photographs from which the ten half-tones illustrating this article are taken.

> We are extensive growers of hops on the Pacific Slope, California and Oregon, and also have about 600 acres of hops in two ranches in British Columbia. For the past three years we have been very much molested in British Columbia by a variety of flea-beetle that seems to take an especial liking to hop foliage and eats the young, tender shoots as they come out of the ground, and also the developed and partly developed leaves of the vines after the same are above ground. There are two other growers in the same section that were bothered one or two years previous to ourselves, and as they had some foreign varieties of hops we at first supposed the insects had been imported from England in the roots. Since, however, we have found that the same insect has been in the neighborhood in very small numbers for quite a long term of years. Our crops in British Columbia suffered quite a bit last season, but this year are very nearly a total failure. From the one place, Chilliwack, B. C., containing 278 acres, we do not expect to reap a harvest of more than 600 bales, whereas we should have from 2,500 to 3,000 bales. From the other place, Agassiz, B. C., we do not expect over 250 bales of hops, whereas we should have 2,250 to 2,700 bales. This will give you some idea of the inroads made by the insect and the resultant loss to persons engaged in hop growing when their yards are attacked by these pests. Of course we readily understand that it would be somewhat out of the ordinary for your Department to attack this problem inasmuch as it is out of the United States, but inasmuch as the pests are now so numerous within about 20 miles of the United States boundary and only a short distance from the Washington State hopyards we believe it is well worth your consideration. Just imagine for a moment the loss that would fall to the numerous growers of hops in the States of Washington, Oregon, or California, if this pest should not be held in check, and would migrate to these sections. We have definite knowledge of their already having spread as far as Sumas Junction, which is on the boundary line between the United States and Canada, where they are attacking cabbage, potato, beets, and other root crops, though the damage done here is not nearly as bad as in the hop fields. * * *

A badly damaged hopyard is shown in figure 13.

During 1908 injury from the hop flea-beetle was reported by Mr. W. W. Stockberger, of the Bureau of Plant Industry of this Department. He mentioned the cases already cited and one reported by Mr. Robert Maitland, of Agassiz, B. C., the latter stating that the ravages of this insect would almost destroy the prospect for a crop during the season. Mr. John Wilson, Agassiz, B. C., who complained of this species in earlier years, reported, under date of July 11, as follows:

> The flea-beetles have been so numerous that they have stripped every portion of the yard this season. I have noticed these last three days that they are all disappearing, but they all disappeared last season about this time and a second brood came about the middle of July.

This "second brood" was probably merely the first-developed generation of the year.

This species has also come under the observation of various other collectors and observers. During 1906 Mr. Frederick Maskew, while working under the writer's direction in southern California, took it generally in many beet fields. Mr. E. G. Titus, while coöperating with this Bureau in the investigation of sugar-beet pests, found it abundantly, and many of the locality records given under the heading "distribution," in California, Utah, Idaho, and other States are from specimens collected by him on sugar beet in 1905, 1907, and 1908.

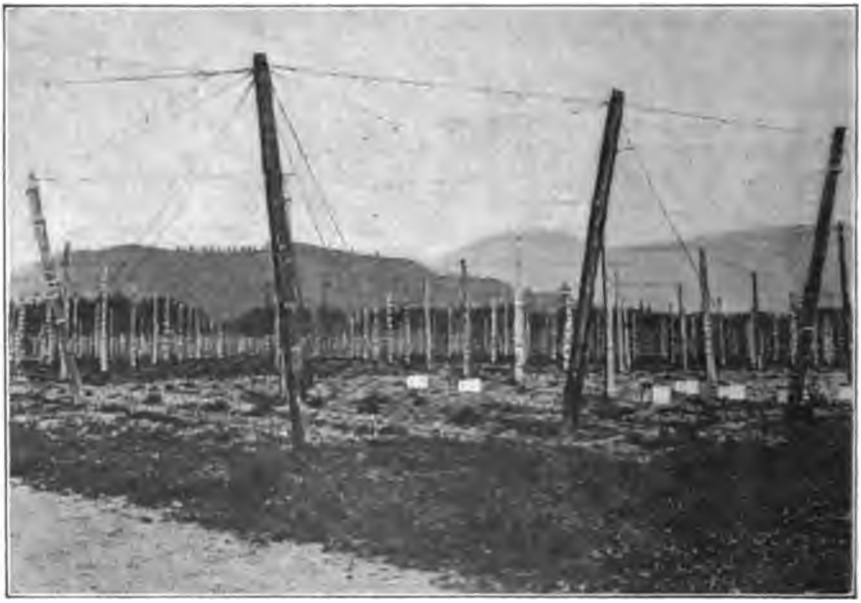

FIG. 13.—View of hopyard, showing how completely the hop flea-beetle keeps down the vines. Note occasional vine that grows up. Agassiz, B. C., June 24, 1908. (Original.)

Writing of this species in July, 1908, Mr. I. J. Condit stated that the beetles were then very common in the vicinity of Chino, Cal., on *Chenopodium album* and *C. rurale*.

METHODS OF ATTACK, FOOD HABITS, AND GENERATIONS.

This flea-beetle affects both surfaces of a leaf, gnawing through the skin and devouring the pulp, usually leaving the skin on the opposite side entire; this later becomes discolored, forming yellowish-brown freckles as the leaf grows and expands, the skin at this point in time becoming torn and frequently showing holes. When the beetle occurs in moderate numbers the leaves (fig. 14) become riddled, as by fine shot, the punctures being most obvious after the plants have made some growth. In its attack on hops it frequently causes the leaves to look like a mass of network or more or less completely strips the vines of leaves, as shown in figures 15 and 16. As is the case with flea-beetles in general, this species does most harm to young plants. When the beetles occur in considerable numbers they are capable of doing great damage in a comparatively short time, completely devouring the young and tender leaves as fast as they come up.

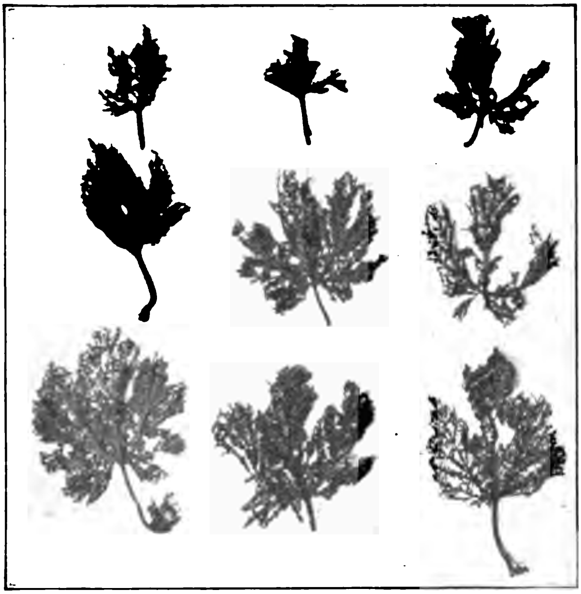

FIG. 14.—Hop leaves, showing work of flea-beetle. (Original.)

Injury is most noticeable on hops, sugar beet, rhubarb, and some other vegetables.

The beetle is a general feeder, the list of its food plants including, among vegetables, rhubarb, beet, cucumber, turnip, radish, cabbage, mustard, and potato. It feeds also on hops, red and white clover, nettle, dock (Rumex), lamb's-quarters (Chenopodium), pigweed and tumbleweed (*Amaranthus retroflexus* and *A. græcians*), hedge mustard, and common wild-growing black mustard. The probabilities are that, as all of these plants are affected by the adult beetles, a considerable proportion of them serves as food for the larvæ. On this head Mr. Quayle has written that the eggs, larvæ, and pupæ were taken at a depth of from three to six inches from the surface of the ground in hop fields and that the larvæ apparently feed on the roots of hop as well as those of other plants growing in the yards. Since it is well known that the beetles occur in other regions where hops do not grow there must be other larval food plants. It would be interesting, and is important, to ascertain exactly what plant, or plants, is the favorite with the larvæ.

Fletcher,[11] in writing of this species, says that in Canada there are two generations a year, the first appearing in June and the second in August. The generation appearing in August is with little doubt the newly developed first generation, and, reasoning from analogy, i. e., from what we know of related flea-beetles, it is this generation of the beetle that hibernates; thus the so-called "first generation" is simply that same generation reappearing the following spring and early summer

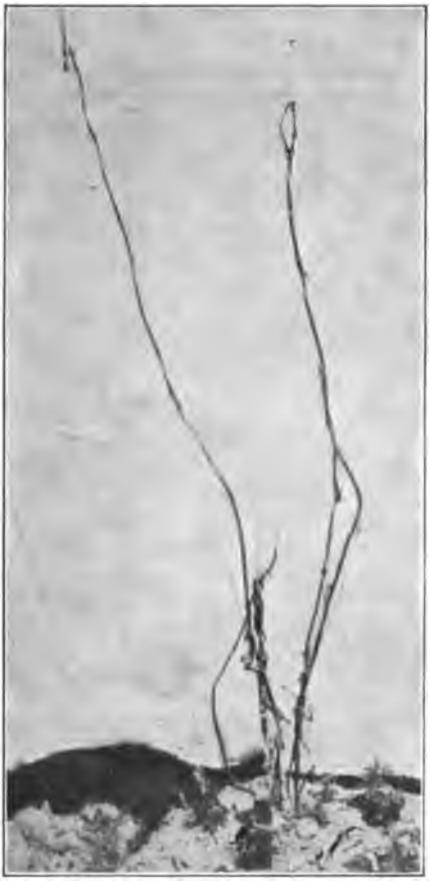

FIG. 15.—Work of flea-beetle after vines are grown. (Original.)

As to hibernation, Piper[6] and Doane[8] have recorded that the beetle passes the winter under stones or rubbish, in which respect it resembles practically all other species of American flea-beetles, and that with the first warm days of spring the beetles emerge from their winter quarters and immediately commence feeding voraciously upon their various food plants.

The following account of the life history and habits of the species in the worst affected locality in British Columbia has been kindly furnished by Mr. H. J. Quayle, who has also given an account of remedial experiments which supplement those previously furnished by conversation with Mr. Eder; indeed, without the information supplied by these two gentlemen this article would be quite incomplete. Before transcribing Mr. Quayle's account it may be well to draw from it, according to the statement of Mr. H. Hulbert, Sardis, B. C., that this species made its first appearance as a hop pest in British Columbia in 1894 and that it has been of great importance for five years, or since about 1903. In regard to Mr. Hulbert's statement that the beetles disappear about June 1 and reappear the last of July, it is obvious that during that period the larvæ are maturing, the pupæ are formed, and the beetles of the first, or new, generation appear.

The following account of the life history and habits of this species as it occurs in British Columbia is taken from Mr. Quayle's manuscripts:

LIFE HISTORY AND HABITS.

The adult.—The beetle appears very early in the spring and, according to reports, patiently awaits the coming of its food plant. This early attack of the beetle as the plants are bursting through the ground and before the leaves are fully expanded is one of the things that makes control work difficult. Before the hops appear the beetles are known to attack the nettle, and often completely riddle the leaves. They also attack other plants, and have been seen, and evidence of their work noticed, on potato, mangel, beet, turnip, dock, lamb's-quarters, pigweed, and red as well as white clover. None of these plants is attacked, however, in preference to hops and it is rarely that they are found at this season on anything but hop vines. In one or two cases they were observed in some numbers on potato, at a considerable distance from hop vines. On a small field of hops that was deserted last year on account of this flea-beetle and planted to clover, the leaves of the latter were considerably eaten.

The first appearance of the beetles in this section, according to Mr. Hulbert, was fourteen years ago, and they have been attacking his hops for the past five years. The beetles jump very readily when disturbed, but fall to the ground, usually not far from the base of the vine. Experiments to determine the power of jumping, which is an important factor in control work, indicate that they may not jump more than a foot in the vertical and about a foot and a half in the horizontal.

Feeding occurs almost entirely on the upper surface of the leaves, where they eat out small, nearly round holes about one-eighth of an inch in diameter. This is continued until the leaf is reduced to a network and finally nothing but the main ribs remain. Many of the vines grew to a height of three or four feet, then the foliage was completely stripped off, leaving the dead stalks, which may still be seen in the fields. Many of the vines are thus killed to the ground. Strings were put in place in 1908 in anticipation of the usual crop, but were taken down and saved for another year, as the vines that started afterward were too late to make a crop. Cultivation was stopped and a thousand sheep were imported from California by the Horst Company to feed in their yards.

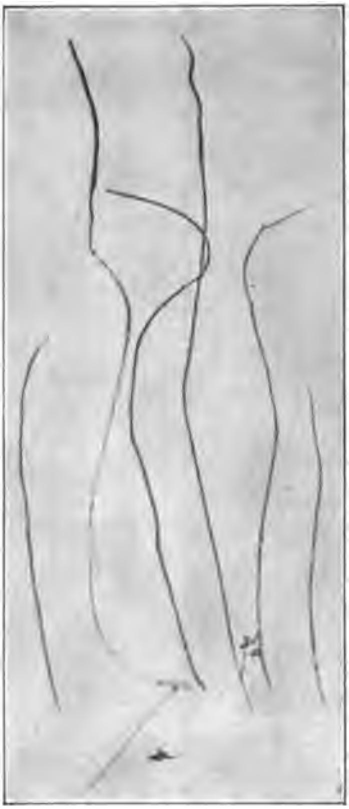

FIG. 16.—Trained hop shoots stripped by flea-beetle. (Original.)

The beetles, with their more or less cone-shaped bodies, readily make their way through anything into which they can get their heads, and our experimental cages [fig. 17], which were covered with cheese cloth, had to be recovered with calico. They also make their way through the soil with little difficulty. Experiments to determine this point consisted in burying them at different depths, enclosed in tin cylinders. In two days the beetles appeared through 2, 4, and 6 inches of loose soil, but did not appear from these same depths where the soil was made compact by tamping.

The egg.—A few eggs have been taken on the hop roots about 4 inches below the surface. Obviously, these are most difficult to find and can not be detected at all without a magnifier. To more easily obtain the eggs and younger stages, tin cylinders, 8 inches in diameter and 2 feet high, have been sunk to a depth of 8 inches in the ground, some enclosing hop vines and others in the open field. Large numbers of beetles have been liberated in each of these, and they will be taken up with the soil intact in the tins in two, three, and four weeks, and the soil carefully examined for eggs and larvæ. Beetles taken in mating, and enclosed in vials with earth at the bottom, have laid eggs in from eight to ten days.

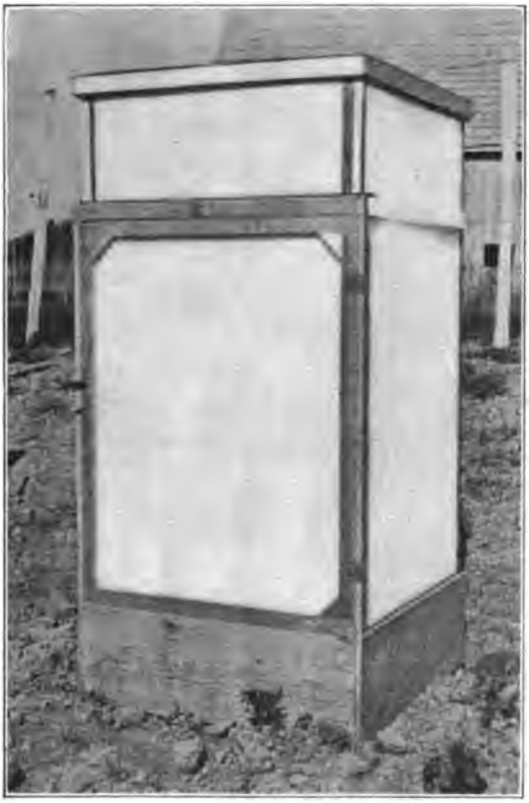

FIG. 17.—Breeding and control cage in place over a hill. (Original.)

The larva.—Larvæ of what the writer believes to be this flea-beetle have been taken from 2 to 4 inches below the surface, both around hop roots and in the spaces between the vines away from any hop roots. While most of the larvæ have been taken about hop vines, I think that they are not restricted, in feeding, to the roots of the hop exclusively, since some have been taken in spaces between the hop vines and also because of the wide distribution of the beetle, both in the United States and in the valleys of the Chilliwack and Agassiz, away from any hopyards. Search about the roots of the nettle and other plants growing along the borders and roadsides failed to reveal any larvæ.

The pupa.—We have also taken pupæ of what was considered this flea-beetle. Transformation to the adult was, of course, necessary to establish this positively and some of the pupæ taken to the laboratory duly transformed. These were taken about the hop roots 3 or 4 inches below the surface.

Both larvæ and pupæ, when sought at the same time, were extremely scarce, and sometimes an hour's search would result in finding nothing. Earlier in the year would undoubtedly be a more opportune time for getting the younger stages, but our rearing-cage experiments, starting with the beetles in mating, should give us ample material for the study of the younger stages. The scarcity of the larvæ at the time when sought is attributed by the writer to the fact that it was too late for the large numbers of spring and too early for those expected to appear about six weeks later, according to reports of previous years. Those few which were obtained are probably late individuals of the last brood.

Two other kinds of larvæ are taken commonly in the ground, these being wireworms and carabid larvæ. Many of these are very small, just about the size of our flea-beetle larvæ, and the wireworms, when first hatched, are of the same white color, but both of these forms of larvæ can be readily distinguished from the flea-beetle larvæ. The few pupæ obtained are undoubtedly those of what we consider the flea-beetle.

Development.—From all accounts this flea-beetle keeps emerging continuously throughout the season, though there are periods when the beetles occur much more abundantly than at others. Last year Mr. Hulbert stopped using the tarred boards June 1, when practically all of the beetles had disappeared. They did not reappear until the last week in July, when the jarring method was resumed. This year (1908) he continued the use of the tarred boards up to the second week of July, this difference over 1907 being attributed to the cold wet season. According to this, the next lot of beetles may not appear before the last of August of the present year. Beetles have been seen breeding continuously during the past two weeks, though not abundantly, one pair being seen out of seventy-five or one hundred beetles. Beetles are usually present in considerable numbers in the fall, when the hops are mature, and do much direct injury to the product.

NOTES ON OTHER SPECIES.

A few remarks in regard to the larval habits of our other American and some European species of Psylliodes may be interesting. The writer has several times observed the beetles of the equally well-known *Psylliodes convexior* Lec. in numbers on shepherd's purse (*Bursa bursa-pastoris*) in June near the District of Columbia, and it is probable that this is the larval food plant. Until the publication of Mr. Quayle's article [12] there was no record of any of our four species having been reared; hence, the natural conclusion that they were root-feeders. In Europe no less than forty-nine species of Psylliodes are recognized in a recently published catalogue,[a] and the habits of those which have been studied indicate a preference for cruciferous plants, although several are attached to widely different groups of plants. Thus among European species are the hop flea-beetle (*Ps. attenuata* Koch), the potato flea-beetle (*Ps. affinis* Payk.), and a species which is mentioned and figured by Taschenberg[b] as the "raps-erdfloh" (*Ps. chrysocephala* L.). The last is very abundant and has been known for years to attack edible cruciferous crops. It has been recently treated (1906) by Mr. Geo.

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[a] Reitter, Catalogus Coleopterorum Europæ, pp. 572–574, 1906.

[b] Praktische Insekten-Kunde, Pt. II, p. 303, fig. 79. Bremen, 1879.

H. Carpenter as a cabbage pest in an article in which the larva is described and illustrated in detail. As to its biology Mr. Carpenter[a] reaches the conclusion that the female beetle lays her eggs on the underground part of the stem and that the young larva burrows through into the interior and feeds in the central tissue of the stem and taproot until mature. The papal stage lasts about three weeks and is passed in an earthen cell just beneath the surface. The natural larval food plant is evidently a wild crucifer.

LOCAL CONDITIONS AND NATURAL INFLUENCES.

Inquiry was made of Mr. Eder during his visit to Washington, D. C., in December, 1908, as to the local conditions in the infested area. From what was learned through him it would appear that the insect's occurrence in such great numbers in the hopyards of British Columbia was due to the equable temperature and to the humidity, which keeps the soil practically always sufficiently moist for the operations of the larvæ feeding beneath the surface.

There can be no doubt, from the writer's observations of our eastern flea-beetles, that these are largely held in check, especially in regions like the District of Columbia, by the extremely dry heat of midsummer. At the time that the flea-beetles are developing as larvæ or undergoing their transformation the ground is nearly baked by the heat during the day and softened only by dews at night. The conditions are very different in British Columbia, and there are, moreover, no other natural causes known which might assist in depleting the numbers of the little pest.

Among natural agencies only a single species of insect has as yet been discovered preying upon this flea-beetle, a hymenopterous parasite which was known to Fitch[2] and which he mentions as a "Chalcidian." It is evidently a species of Perilitus, probably the same species, *schwarzii* Ashm. (?), as has been encountered by the writer on other species of flea-beetles of the genera Epitrix and Phyllotreta. It develops within the body of the adult or beetle. It is not known if this species occurs also in the Pacific region. If not, it might be possible to introduce it.

Fitch's observations and conclusions are interesting, since we have no reason to doubt his theory. Briefly he observed on June 4, 1863, two flea-beetles pairing on a leaf of rhubarb. Presently a parasite alighted near them. It darted upon the back of the female, appearing to be inserting its sting in the tip of her body, whereupon she gave a leap and they both disappeared among the foliage. Fitch conjectured that the "chalcidian" was an egg-parasite of the flea-beetle and that the eggs of the latter were so minute that the larval parasite required several of them to nourish and bring it to maturity, as observed of an egg-parasite of the Hessian fly. The parent, watching her opportunity, deposits an egg internally in the ovaries of the flea-beetle, or in the passage-way therefrom, and the parasite larva, taking up its residence there, consumes the eggs of the flea-beetle, one after another, as they develop, whereby none of them will be extruded until after the parasite has attained its growth. In conclusion he writes, "Most singular and truly wonderful as such a provision of nature would be, it is the most probable conclusion I am able to arrive at from past observations."

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[a] Journal of Economic Biology, Vol. I, pp. 152–156, Pl. XI. London, England, November, 1906.

METHODS OF CONTROL.

Correspondents who have inquired for a direct remedy for use against this species have been advised to experiment with all of the usual flea-beetle remedies. These are, in brief, arsenate of lead. arsenate of lead with resin-fishoil soap, Paris green with and without Bordeaux mixture, Scheele's green, arsenite of lime with soda, dry Paris green with air-slaked lime, Bordeaux mixture alone, and kerosene emulsion. According to Messrs. Eder, Quayle, and others, most of these remedies have been tested more or less completely without being found to be thoroughly effective, owing to the great numbers of the flea-beetles and the rapidity with which the tops of the hop vines grow. All remedies that have been employed have been directed against the beetles only. Unless the hop plants are sprayed nearly every day it is practically impossible to keep them covered with any poison so as to entirely protect them from the ravages of the "fleas." Among other substances tested were tarred boards and sheets, as for leafhoppers. On account of the employment of cheap labor, chiefly Hindu, mechanical and hand methods were found of some value. Snuff was found effective on a small scale and finely powdered tobacco, such as is now on the market as an insecticide, is to be tested.

According to Messrs. Quayle, Eder, and others, the difficulties encountered in the economic treatment of this species are due to two causes: (1) The continual emergence or appearance of the beetles, rendering any method that has yet been employed, such as an arsenical or contact spray, or any mechanical means of capture, such as jarring, of only temporary value, and (2) the extremely rapid growth of the young hop vines, making frequently repeated applications of a spray or other direct remedy a necessity.

ARSENICALS.

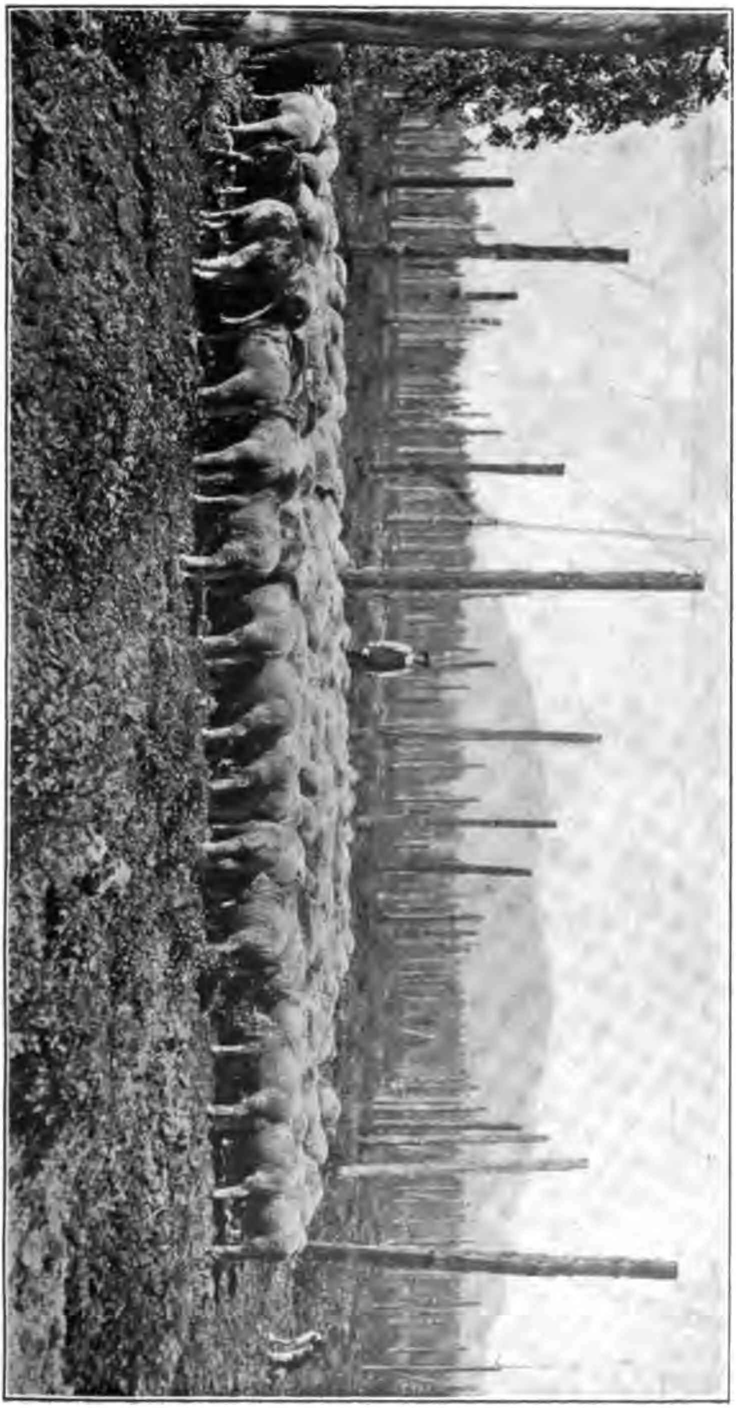
Arsenate of lead.—Arsenate of lead, applied at the rate of about 1 pound in from 20 to 50 gallons of water, is advised for use against the hop flea-beetle. Being more adhesive, this mixture, when sprayed upon the plants, sticks more firmly to the leafage than Paris green, and is also very much less likely to produce scorching or burning; indeed, it has been used at 1 pound to 10 gallons of water on some of the hardier plants, such as potato, without injurious effects. This is, however, not advisable, owing to the extra cost, provided that a weaker solution will accomplish the object. Moreover, scorching is apt to follow its use at this rate on some plants, especially when these are exposed to the direct rays of the sun. The adhesiveness is still further enhanced by the addition of about the same amount by weight of resin-fishoil soap as of the arsenical employed. Mr. Wilson reported that arsenate of lead, applied at the rate of 4 pounds to 40 pounds of Bordeaux mixture, was inadequate, yet Mr. Quayle reports that used at the rate of 5 pounds to 50 gallons it will kill a large number of the beetles, although many take to the new growth that is constantly appearing, or apparently carefully avoid those places on the foliage that have a good coating of poison. The failure of these two arsenicals must be attributed, in large part, to unsuitable spraying apparatus; either of these applications should kill insects on hops, as they have both been found effective, according to Fletcher, against this same beetle on rhubarb in the Northwest Territory and Manitoba.

Dry Paris green.—Mr. Thos. Cunningham reported that very little impression was made by an arsenical spray in the region just mentioned, but stated that Paris green dusted on the plants seemed to produce better results. It was applied by means of a Leggett powder gun. Even then some trouble was experienced; in fact, as the arsenical dust or so-called " dust spray " struck the vines the " fleas " hopped to the ground. " In all my experience with insecticides," he says, " I have never seen anything which will approach the fleas in resistant power."

Paris green spray.—Paris green, being the most readily obtainable insecticide, was advised by this Bureau when information as to remedies was requested. When properly prepared and applied, according to the directions furnished in Farmers' Bulletin No. 127, this insecticide should have no deleterious effect on the hop or other plants affected. It was advised that other food plants growing in the vicinity, such as rhubarb, turnips, and weeds, should be sprayed with the solution.

Regarding its efficiency in hop fields Mr. John Wilson, in a report to the late Doctor Fletcher, stated that when applied at the rate of from 4 to 8 ounces, in combination with Bordeaux mixture, made according to the 4–4–40 formula, or in 40 gallons of water, it was not successful.

PLATE VI.



Hop Fields from which Training Twine was Removed in June or July, Photographed in August.

Beetles abated somewhat the last of July and hops began to put out new shoots. Weed growth kept down by sheep pasturage. Hop-leaf growth pastured very close in fall. (Original.)

abouts, and thrown into hot water, and after drying will be available for use in other seasons.

If, with another year's experience, we could ascertain how best to control the insect, either by killing the beetles with arsenate of lead or other arsenical, kerosene emulsion, or whale-oil soap, or by destroying the larvæ in the ground, the problem would be partially solved. One, two, or perhaps even three of these remedies might be used in combination and excellent results obtained. In any case, if we can partially control the insects by any one of them we should not forget that cultural remedies, and especially clean culture, are the most valuable remedies that can possibly be employed against insect pests. Indeed, with many species, if cultural practices were properly followed out, with the cooperation of our neighbors, insecticides would in the course of time, after the balance of nature had been restored, seldom be needed save in case of severe outbreaks, which are likely to occur more or less spasmodically with most of our noxious insects.

LITERATURE.

A complete bibliography of this species is appended and only a brief review of published accounts need be given. The original description of the species appeared in 1847,[1] and it was not until twenty years later that we had any record of the insect's habits. In 1867 Fitch[2] wrote a two-page account regarding injury to cucumber, rhubarb, and radish, furnishing notes on a parasitic natural enemy. In 1884 our first account of injury to hops, a brief one, was written by Dr. J. B. Smith.[4] These accounts were followed by one from Piper[6] on injuries to certain truck crops in Washington State in 1895 and by Doane[8] of similar injuries in 1900. The writer[7] noted the abundance of the species on rhubarb near Washington, D. C., in 1897. Forbes and Hart[9] have given a brief account of the insect from the standpoint of its injuries to sugar beet in Illinois, and Fletcher[10, 11] published two accounts of the species in 1904 and 1907, respectively. In 1908 was published H. J. Quayle's article,[12] in which first mention is made of the larval habits of the insect.

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    Mere mention as affecting hops at Sardis, B. C., in noticeable numbers.

11. Fletcher, Jas.—Rept. Entom. and Bot. Canada for 1906 (1907), p. 215.

    Account of injuries in the Fraser River Valley, B. C., in 1906, with quotations from John Wilson, Agassiz; Thos. Cunningham, Vancouver; and H. Hulbert, Sardis, B. C., which include experiences with remedies.

12. Quayle, H. J.—Journ. Econ. Ent., Vol. I, p. 325, October, 1908.

    A short article, with notes of injury in British Columbia; account of habits, all stages, including the egg, being taken 3 to 6 inches from the surface of the ground, larvæ feeding at the roots of hop and other plants growing in the yards; list of food plants, and difficulties of applying remedies.

SUMMARY.

The hop flea-beetle, a minute, black insect, feeds on various succulent plants. It does serious damage to hops in British Columbia and less injury to sugar beet and vegetable crops in the Pacific coast region.

Its life history is only partially known, but all stages have been found about the roots of hops and the larva probably feeds on most of the same plants as the adult. It is feared that this species may become an important hop-pest in Washington and Oregon, and it doubtless does more injury to beets than is generally accredited to it. Injury is most severe to young plants, but on sugar beet the operations of the beetles throughout the season undoubtedly have a deleterious effect and necessarily decrease the yield.

The abundance of the beetles when they appear early in the season on young plants, their constant reappearance, and the constant new growth of the plants from day to day make it difficult to apply direct remedies with more than temporary benefit. Where the hops are sprayed with kerosene emulsion or whale-oil soap for the hop aphis the numbers of the beetles are lessened. Among measures which give promise of value are the institution of clean methods of cultivation, including deep fall plowing, treating hop poles in such manner as to prevent the beetles from hibernating in them, and clearing all remnants from fields so as to leave them as bare as possible to prevent the beetles from sheltering there in winter. Arsenate of lead, Paris green, kerosene emulsion, whale-oil soap, and Bordeaux mixture should receive further tests, as should the employment of trap crops in the manner advised in this article.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 66, Part VII.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

MISCELLANEOUS NOTES ON TRUCK-CROP INSECTS.

BY

F. H. CHITTENDEN, Sc. D.,
In Charge of Truck Crop and Stored Product Insect Investigations.

ISSUED JULY 19, 1909.

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U. S. D. A., Bul. 66, Part VII. Issued July 19, 1909.

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By F. H. Chittenden, Sc. D.,
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SUCCESSFUL USE OF ARSENATE OF LEAD AGAINST THE ASPARAGUS BEETLE.

During the first week of June, 1908, Mr. W. A. Orton reported the common asparagus beetle (*Crioceris asparagi* L.) very injurious at Takoma Park, D. C., and made some experiments with arsenate of lead with complete success. Directions for application, as given in Circular 102 of this Bureau, were followed. The first application was made with 1 pound of arsenate of lead to 20 gallons of water and the second a week later, as the plants had grown rapidly in the meantime and a great many new larvæ had hatched. The second application was made at the rate of 1 pound to 15 gallons of water. The first application destroyed most of the insects, but after a few days a considerable number had developed. These appeared to have been all killed the day after the second spraying. Neither spraying seemed to injure the plants in the least, but the liquid adhered in fine drops to the foliage and was visible there for some time. An unsprayed plat on a neighbor's place was considerably injured by these insects, and up to July 1 no more had appeared on Mr. Orton's crop. He pronounced the treatment very effective. The work was done with a compressed-air machine or autospray.

Mr. Edward A. Eames, Buffalo, N. Y., writing of the value of arsenate of lead as a means of combating the common asparagus

Note.—The accompanying Part VII includes short notes on some of the insects which have been treated in earlier parts of this bulletin and notes on two insects not hitherto recorded as injurious in the United States. To the former class belong notes on the asparagus beetles and the asparagus miner, species considered more in detail in Part I, pages 1–10, and notes on water-cress insects in addition to what has been published in Part II, pages 11–20. To the second class belong notes on the injurious occurrence of the pea moth in the United States and a short account of a new western root-maggot.—F. H. C.

beetle, stated that the larvæ of this species threatened to devour his this year's spring-set asparagus to the ground. But after one thorough spraying with arsenate of lead it was difficult to find any but dead larvæ on the plants. Successive sprayings were of course necessary, because the beetles continued to come from neighboring gardens to deposit eggs on the plants and because the developing plants continually presented fresh unsprayed foliage for larval food.

Mr. Eames stated positively that arsenate of lead adhered well, even through several rains, just as its various promoters claimed—a fact which justifies its use in any case even at more initial cost than other poisons which might be used. He also expressed the view that asparagus growers generally should be impressed with the fact that, because of the tendency to spray only once, additional information should be given of the value of extra applications. In conclusion, he stated that he believed arsenate of lead was a specific for this class of insects.

Our correspondent is undoubtedly right. It seems to be as nearly a specific for asparagus beetles as anything that can be obtained, provided it is applied according to directions and that applications are repeated as often as necessary. The trouble is that many truck growers, after spraying a single time, consider that the matter should then be dropped, and if the desired result is not produced, i. e., if the trouble is not wholly stopped, the spraying is condemned or at any rate the insecticide is discontinued, while all that is necessary for the entire season is a second or third application.

A NOTE ON THE ASPARAGUS MINER.

The asparagus miner (*Agromyza simplex* Loew) was reported by Mr. I. J. Condit in the vicinity of Antioch, Cal., August 19, 1908, where the common asparagus beetle was also abundant. The miner was said to be equally numerous and stalks showing infestation were received. The miner-infested stalks could generally be detected by their roughened appearance near the ground.

This species was also taken by Mr. Condit at Oakley and it seems probable, since the common asparagus beetle is found in both localities, that it is becoming generally distributed in California. In one place at Oakley Mr. Condit observed the miner quite common on some stalks, but it did not appear to be equally common over the entire ranch.

During October, 1908, the writer observed this species well established on asparagus in the vicinity of Portsmouth, Va. In October, also, Mr. J. B. Norton reported very severe injury to asparagus in the vicinity of Concord, Mass. The roots of the plants were not only girdled, but the miners worked up the stalks some inches above the ground.

INJURIOUS OCCURRENCE OF THE PEA MOTH IN THE UNITED STATES.

Prominent among the injurious occurrences of the year 1908 was the discovery of the pea moth (*Enarmonia nigricana* Steph.) for the first time in the State of Michigan. August 10 we received from Mr. J. E. W. Tracy, Bureau of Plant Industry, specimens of the larva of this species and its work in growing peas and pods from Charlevoix, Mich.

Mr. Tracy wrote that he obtained the specimens on that day and some days earlier and that Mr. E. W. Coulter and others in that vicinity knew nothing of the identity of this insect, which was causing them considerable concern. The caterpillar first showed itself in very small numbers four or five years before, but it had increased rapidly until the year of writing, when 15 per cent of the peas were ruined. The insect appears to start operations by eating the embryo stem and then moves along the pod until it makes its exit and disappears. Early varieties of peas were the worst sufferers in the affected district. At the time of writing our correspondent found a less number of living larvæ than previously.

This appears to be the first record of the appearance of this insect in the United States, although it has been known as a pest in Canada for several years and has undoubtedly been present in our Northern States, where peas are grown, without having been recognized as anything new or unusual.

A two-page account of this species has been published by the writer in Bulletin No. 33, pages 96–98, which includes a brief illustrated description of the moth and larva and a consideration of the distribution, nomenclature, history, habits, and remedies.

This insect first came to notice near Toronto, Ontario, in 1893, and notices of its ravages in Canada were given in several subsequent years by the late Dr. James Fletcher in his report as entomologist and botanist of the Dominion of Canada. It is an importation from the Old World and is well established in New Brunswick and Nova Scotia as well as in Ontario, and is also recorded from Manitoba.

The name of this species was omitted from the Dyar catalogue of Lepidoptera, but is included in Smith's Check List of Lepidoptera under No. 5702. In most publications the species is mentioned as *Semasia nigricana.*

A NEW WESTERN ROOT MAGGOT.

August 16, 1907, Mr. E. M. Ehrhorn sent from San Francisco, Cal., some radishes, the roots of which were affected by a maggot. The adults were reared September 3 to 20 and were referred to Mr. D. W. Coquillett for identification. They were first mistaken for *Pegomya cepetorum*, because of the very close relation of the two species, but when more material of both sexes was obtained they were seen to be different. Mr. Coquillett states that some individuals have the bristles practically as in *cepetorum*, but in the males the median black stripe of the abdomen is continuous. This material corresponds so well with Stein's description[a] of *Chortophila planipalpis* as to leave no reasonable doubt of the species. The type locality is Idaho. The insect will therefore be known as *Pegomya planipalpis* Stein, and may be called the western radish maggot. Another lot of the maggot was received from the same source October 1, larvæ and pupæ both being present. From this lot adults issued November 1 to 21.

November 21, 1908, we received from Mr. Charles Heise, Aberdeen, Wash., a section of turnip mined by larvæ which are probably of this species, as also a number of puparia. Our correspondent stated that his observations showed that the maggot works on onions as well as on turnips. As we do not know to the contrary, and do not know positively of the occurrence of any onion maggot in that State, this surmise may be correct. It remains to be verified or disproven. The seed-corn maggot (*Pegomya fusciceps* Zett.) occurs in that region and is more apt to be the onion-feeding species.

Two natural enemies of this radish maggot have come under observation and have been identified by Mr. J. C. Crawford, as follows:

Aphæreta sp.—September 3, 1908, many braconids of a species of the genus *Aphæreta* emerged from material in which this root-maggot was breeding in infested radish from San Francisco, Cal. It is a small species, shining black in color, with dusky wings and yellow legs. In some specimens there are 21 joints to the antennæ on one side and 22 on the other. It is very similar to the type of *muscæ*, but is larger.

Polypeza sp.—This species was reared from its host October 10, 1907, and appears to be undescribed.

NOTES ON WATER-CRESS INSECTS.

The water-cress leaf-beetle.—May 2, 1907, Mr. J. W. Bryan brought to this office from Halltown, W. Va., specimens of the water-cress leaf-beetle (*Phædon æruginosa* Suffr.), present in the beetle and larval forms, the larvæ at that time about half grown. The beetles were beginning to die and a fungus attack was noticed when received. Numerous individuals of the beetle and one larva were parasitized by the fungus. The fungus was tentatively determined by Mr. Haven Metcalf, Bureau of Plant Industry, as *Entomophthora sphærosperma*. If this identification is correct, there can be no doubt that the fungus attacked the insect before death, and may therefore be a factor of value in its natural destruction.

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[a] Berl. Ent. Zeitschr., Vol. XLII, pp. 234-235, 1897.

Since the publication of the writer's preliminary articles on the water-cress leaf-beetle and sowbug in the present bulletin (pp. 11–20) it has been noticed that earlier accounts of the related European *Phædon betulæ* L., known as the mustard beetle and "blackjack," were made by Miss E. A. Ormerod, who furnished several references with illustrations in her manual.[a] From this account it appears that injury was first noticed, at least in England, in 1854, to white mustard crops near Ely. Another account of this insect is given in the same author's report for 1886.[b]

The water-cress sowbug.—April 16, 1907, Mr. C. A. Killinger, Shippensburg, Pa., sent specimens of the water-cress sowbug (*Mancasellus brachyurus* Harg.) in different stages, stating that it was destroying his water cress, working on the leaves under water, cutting them close to the stem. If the cress is light or does not grow fast, as happens in winter, they also work on the stems and roots, cutting the plants loose and causing them to float downstream. Our correspondent thought that this species was brought to that section from Virginia.

Experiments conducted with lime in a small spring the previous summer succeeded in killing most of the sowbugs, but plenty of them remained at the time of writing. The lime, however, burned the cress, causing it to turn yellow.

December 23, 1908, Mr. F. W. Houston, a grower and shipper of water cress at Lexington, Va., wrote of this species, inquiring for literature and a remedy. He stated that he had a spring under cultivation that was infested with the water-cress sowbug, and later—March 11, 1909—he sent specimens. In this connection he wrote as follows:

> I have a spring under cultivation which has been infested by them for several years. I fought them for a time by putting the water into ditches and exposing the rest of the cress bed to the sun. In these ditches I would make frequent applications of lime; this, of course, was done during the early summer, after the shipping season closes. It seems to kill all of the sowbugs, but when I put the water into the beds and reset the cress, hauling it from an uninfested spring, it was not long until the "bugs" were again noticed, and in a short time they were as thick as ever.

Mr. Houston was advised that in the case of the old beds the water should be drawn or turned off and that the cress should be completely destroyed and the spring reset with uninfested cress.

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[a] Manual of Injurious Insects and Methods of Prevention. London, 1890, pp. 151–156.

[b] Report on Injurious Insects for 1886, pp. 59–60.

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O

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 67.

L. O. HOWARD, Entomologist and Chief of Bureau.

PROCEEDINGS

OF THE

NINETEENTH ANNUAL MEETING

OF THE

ASSOCIATION OF ECONOMIC ENTOMOLOGISTS.

ISSUED NOVEMBER 25, 1907.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

BUREAU OF ENTOMOLOGY.

L. O. Howard, *Entomologist and Chief of Bureau.*
C. L. Marlatt, *Entomologist and Acting Chief in absence of Chief.*
R. S. Clifton, *Chief Clerk.*

F. H. Chittenden, *in charge of breeding experiments.*
A. D. Hopkins, *in charge of forest insect investigations.*
W. D. Hunter, *in charge of cotton boll weevil investigations.*
F. M. Webster, *in charge of cereal and forage plant insect investigations.*
A. L. Quaintance, *in charge of deciduous fruit insect investigations.*
E. F. Phillips, *in charge of apiculture.*
D. M. Rogers, *in charge of gipsy moth and brown-tail moth work.*
A. W. Morrill, *engaged in white fly investigations.*
W. F. Fiske, *in charge of gipsy moth laboratory.*
W. A Hooker, *engaged in cattle tick life history investigations.*
A. C. Morgan, *engaged in tobacco insect investigations.*
R. S. Woglum, *engaged in hydrocyanic acid gas investigations.*
C. J. Gilliss, *engaged in silk investigations.*
R. P. Currie, *assistant in charge of editorial work.*
Mabel Colcord, *librarian.*

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., July 20, 1907.

Sir: I have the honor to transmit herewith the manuscripts of the proceedings of the nineteenth annual meeting of the Association of Economic Entomologists, held at New York, N. Y., December 28 and 29, 1906. This association, made up largely of entomologists connected with the State experiment stations, the Bureau of Entomology of this Department, and others engaged officially in entomological work, is an important one, and the proceedings of its annual meetings contain papers and discussions on injurious and beneficial insects which should by all means be put in print. I therefore recommend that, following the custom of previous years, the proceedings of this meeting be published as Bulletin No. 67 of this Bureau. The two plates and six text figures are necessary for proper illustration of the text.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE NINETEENTH ANNUAL MEETING OF THE ASSOCIATION OF ECONOMIC ENTOMOLOGISTS.

MORNING SESSION, FRIDAY, DECEMBER 28, 1906.

The association met in room 516, Schermerhorn Hall, Columbia University, New York, N. Y., at 10 a. m. An average attendance of over 75 members and visitors was present at each session on Friday and Saturday. The following members attended the meeting:

E. A. Back, Amherst, Mass.; E. D. Ball, Logan, Utah; Rev. C. J. S. Bethune, Guelph, Canada; William Beutenmuller, New York, N. Y.; F. C. Bishopp, Washington, D. C.; W. E. Britton, New Haven, Conn.; F. E. Brooks, Morgantown, W. Va.; A. F. Burgess, Columbus, Ohio; F. H. Chittenden, Washington, D C.; R. S. Clifton, Washington, D. C.; J. H. Comstock, Ithaca, N. Y.; Mel. T. Cook, New York, N. Y.; D. W. Coquillett, Washington, D. C.; C. R. Crosby, Ithaca, N. Y.; E. L. Dickerson, New Brunswick, N. J.; H. G. Dyar, Washington, D. C.; E. P. Felt, Albany, N. Y.; H. T. Fernald, Amherst, Mass.; James Fletcher, Ottawa, Canada; H. L. Frost, Arlington, Mass.; A. B. Gahan, College Park, Md.; J. B. Garrett, Baton Rouge, La.; J. A. Grossbeck, New Brunswick, N. J.; T. J. Headlee, Durham, N. H.; W. E. Hinds, Washington, D. C.; H. E. Hodgkiss, Geneva, N. Y.; W. A. Hooker, Washington, D. C.; A. D. Hopkins, Washington, D. C.; C. O. Houghton, Newark, Del.; L. O. Howard, Washington, D. C.; W. D. Hunter, Washington, D. C.; G. B. King, Lawrence, Mass.; A. H. Kirkland, Boston, Mass.; D. K. McMillan, Harrisburg, Pa.; C. L. Marlatt, Washington, D. C.; A. C. Morgan, Washington, D. C.; Dudley Moulton, Washington, D. C.; Herbert Osborn, Columbus, Ohio; P. J. Parrott, Geneva, N. Y.; E. F. Phillips, Washington, D. C.; J. L. Phillips, Blacksburg, Va.; A. L. Quaintance, Washington, D. C.; F. W. Rane, Boston, Mass.; W. E. Rumsey, Morgantown, W. Va.; J. G. Sanders, Washington, D. C.; E. D. Sanderson, Durham, N. H.; William Saunders, Ottawa, Canada; Franklin Sherman, jr., Raleigh, N. C.; Henry Skinner, Philadelphia, Pa.; M. V. Slingerland, Ithaca, N. Y.; J. B. Smith, New Brunswick, N. J.; R. I. Smith, Atlanta, Ga.; E. B. Southwick, New York, N. Y.; H. E. Summers, Ames, Iowa; T. B. Symons, College Park, Md.; E. P. Taylor, Fort Collins, Colo.; E. S. G. Titus, Washington, D. C.; B. H. Walden, New Haven, Conn.; F. L. Washburn, St. Anthony Park, Minn.; F. M. Webster, Washington, D. C.; and G. P. Weldon, College Park, Md.

Among the visiting entomologists were the following:

H. G. Barber, Gustav Beyer, Henry Bird, E. A. Bischoff, H. H. Brehme, J. R. de la Torre Bueno, William T. Davis, Jacob Doll, G. P. Engelhardt, H. J. Erb, George Franck, C. F. Groth, C. W. Johnson, L. H. Joutel, Hugo

Kahl, W. D. Kearfott, G. J. Keller, H. H. Lyman, Ignaz Matausch, J. G. Needham, G. T. Rockwell, Charles Rummel, G. A. Runner, Charles Schaeffer, S. H. M. Seib, F. J. Smith, William Wasmuth, A. C. Weeks, W. M. Wheeler, and Rev. J. L. Zabriskie.

The meeting was called to order by President Kirkland, who called Mr. Hopkins to the chair while he delivered the annual address, entitled "A Great Experiment in Applied Entomology."[a]

Immediately following the president's address the report of the treasurer was read, as follows:

Report of the treasurer.

Envelopes and paper	$1.90
Stamps	5.00
Printing notices and programmes	9.50
Total	16.40

Respectfully submitted.

A. F. Burgess, *Treasurer.*

As no balance was left in the treasury after paying the expenses of the last annual meeting, action was called for on the amendment to the by-laws proposed by the committee on resolutions and printed in the proceedings of the eighteenth annual meeting. After a general discussion, the following amendment was adopted as a substitute for section 2, Article II, of the by-laws: "The annual dues of active members shall be $1 and the dues of associate members 50 cents."

The report of the committee on nomenclature was presented by Mr. Herbert Osborn, chairman, as follows:

REPORT OF COMMITTEE ON NOMENCLATURE.

Your committee, in pursuance of the plan heretofore adopted for getting an expression of opinion as to the general use of common names, distributed, through the secretary, a list of 69 names, and in answer to these criticisms have been received from a number of members from widely different sections and out of the 69 in the list 41 have appeared acceptable to all who have replied, and these are submitted herewith for consideration or adoption at the present meeting. A number of others meet general acceptance, except in minor matters of form, and doubtless may be agreed to in the near future.

In the matter of use of scientific names the committee would recommend that the association adopt and recommend its members in practice to follow the rules of nomenclature adopted by the International Congress of Zoologists, and adhere to them strictly in all technical papers.

That in all economic papers these rules be followed in so far as practicable, and in accordance with the provision adopted in a previous meeting that in any doubtful cases as to generic reference the genus that has been in common use, or that may be adopted in the latest general catalogue of authority, shall be the preferred name.

---

[a] Owing to the pressure of important work Mr. Kirkland has been unable to complete and supply the manuscript of his address.—Ed.

Apple curculio	*Anthonomus quadrigibbus* Say.
Apple twig-borer	*Schistoceros hamatus* Fab.[a]
Black cutworm	*Agrotis ypsilon* Rott.
Book-louse	*Troctes divinatoria* Müll.
Buck moth	*Hemileuca maia* Dru.
Cadelle	*Tenebroides mauritanicus* L.
Cabbage looper	*Autographa brassicæ* Riley.
Chaff scale	*Parlatoria pergandei* Comst.
Cigarette beetle	*Lasioderma serricorne* Fab.
Catalpa sphinx	*Ceratomia catalpæ* Boisd.
Cherry scale	*Aspidiotus forbesi* Johns.
Clover cutworm	*Mamestra trifolii* Rott.
Clover mite	*Bryobia pratensis* Garm.
Currant borer	*Ægeria tipuliformis* Clerck.
Fall armyworm	*Laphygma frugiperda* S. & A.
Forest tent-caterpillar	*Malacosoma disstria* Hbn.
Garden webworm	*Loxostege similalis* Guen.
Gray blister-beetle	*Epicauta cinerea* Forst.
House cricket	*Gryllus domesticus* L.
Imbricated snoutbeetle	*Epicærus imbricatus* Say.
Lappet moth	*Epicnaptera americana* Harr.
Leaf crumpler	*Mineola indiginella* Zell.
Melon caterpillar	*Diaphania hyalinata* L.
Northern mole cricket	*Gryllotalpa borealis* Burm.
New York weevil	*Ithycerus noveboracensis* Forst.
Onion maggot	*Phorbia cepetorum* Meade.[b]
Orange scale	*Aonidiella aurantii* Mask.
Pickle worm	*Diaphania nitidalis* Cram.
Raspberry sawfly	*Monophadnoides rubi* Harr.
Rose sawfly	*Endelomyia*[c] *rosæ* Harr.
Salt-marsh caterpillar	*Estigmene acræa* Dru.
Sheep tick	*Melophagus ovinus* L.
Stable fly	*Stomoxys calcitrans* L.
Strawberry weevil	*Anthonomus signatus* Say.
Turkey gnat	*Simulium meridionale* Riley.
Variegated cutworm	*Peridroma saucia* Hbn.
Walking-stick	*Diapheromera femorata* Say.
White-lined sphinx	*Deilephila lineata* Fab.
Vagabond crambus	*Crambus vulgivagellus* Clem.
Yellow mealworm	*Tenebrio molitor* L.

HERBERT OSBORN, *Chairman*.
F. M. WEBSTER.
C. P. GILLETTE.

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[a] Synonym, *Amphicerus bicaudatus* Say. See Lesne, P.—Revision des Bostrychides. Ann. Soc. Ent. France, vol. lxvii, pp. 513, 514, 1898.—ED.

[b] This species is placed by Coquillett in the genus Pegomya Desvoidy. See Chittenden, Cir. 63, 2d ed., Bur. Ent., U. S. Dept. Agric., p. 6, footnote 2, 1906.—ED.

[c] For reference of this species to the genus Endelomyia see Ashmead, Can. Ent., vol. xxx, No. 10, October, 1898, p. 256.—ED.

Considerable discussion arose concerning the proper use of the hyphen in compound words, and Mr. Slingerland suggested that in the future some standard dictionary be followed as an authority. It was pointed out by Mr. Osborn that the main consideration was to secure the uniform use of common names when applied to insects of economic importance, and that the hyphenization should be considered a minor matter if the other object could be accomplished. Doctor Howard indorsed the part of the report which urged that the rules of nomenclature adopted by the International Congress of Zoologists be followed by the members of the Association, and after a brief discussion the report was adopted.

The report of the committee on cooperative testing of insecticides was read by Mr. H. T. Fernald, chairman.

REPORT OF COMMITTEE ON COOPERATIVE TESTING OF INSECTICIDES.

Your committee on the cooperative testing of insecticides begs leave to report as follows:

It seemed wise to the committee to learn how generally a desire existed for cooperation in this work. Accordingly a circular letter was sent to over 50 of the leading workers in economic entomology in all parts of the country, and answers were received from about half of this number. If these answers fairly represent the general feeling of the entomologists of the country, it seems that the idea of cooperation is almost universally indorsed, though with qualifications in many cases. The other questions asked in the circular were to bring out ideas as to the best methods to accomplish cooperation, and these brought widely divergent answers, hardly any two being in agreement on all points. From a study of all the correspondence, however, your committee recommends the following:

I. That all proprietary insecticides the use of which is restricted to particular localities should be tested, if at all, by the proper authorities in those localities. If they seem to promise wide application as a result, they should then be tested as below.

II. That all proprietary insecticides used or advertised in many parts of the country should be tested as follows:

(*a*) A standing Committee on Insecticides, to consist of five persons elected by this association, should obtain—from the manufacturer if possible—a statement of the composition of the insecticide in each case. If this proves that it could not possibly be of any value or do the work claimed, it should be dropped. If from a statement received from the manufacturers it seems possible that the material might be of some value, a sample should be sent to some chemist for qualitative and quantitative analysis.

(*b*) That, if possible, arrangements be made by which the chemist in charge of the insecticide work of the United States Department of Agriculture shall conduct this portion of the work, the material to be sent him by the standing committee.

(*c*) That if the report of the chemist shows that the material is worthless as an insecticide no further consideration be given to it.

(*d*) That if it appears probable that the material is of some value as an insecticide, samples be sent by the standing committee to several entomologists in different sections of the country, who may signify their willingness to do this work, for the purpose of making cooperative tests of it.

(*e*) That a plan of testing be worked out by the standing committee and sent by it to each entomologist, with the substance, together with a plan for reporting results, so that the factors entering into the test and the data in the reports may be uniform and full.

(*f*) That reports received be compiled and a general report made by the standing committee to this association at its annual meeting.

(*g*) That these reports, or such portions of them as seem advisable, be published by the association and then by others who may wish to publish them.

III. Your committee further recommends that if the above plan or any modification of it be adopted, the committee designated by this association to carry it out be requested to prepare the plans for testing and reporting on the tests and for assigning the materials to the entomologists selected by them to make the tests.

Respectfully submitted.

H. T. FERNALD, *Chairman.*
A. F. BURGESS.
H. A. SURFACE.

On motion this report was accepted and ordered published in the proceedings of the meeting. The appointment of the standing committee suggested was deferred for later consideration. A brief report of the programme committee was made by the secretary and related chiefly to the arrangement of the papers to be presented. A motion was made and carried that the time for the presentation of each paper be limited to ten minutes.

A paper was then read by Mr. Washburn, entitled:

INSECT NOTES FROM MINNESOTA FOR 1906.

By F. L. WASHBURN, *St. Anthony Park, Minn.*

THE CABBAGE MAGGOT.

Flies of the cabbage maggot (*Phorbia brassicæ* Bouché) were first observed May 9. On May 16 egg laying was well under way. On May 31 first maggots were observed. On June 5 maggots were exceedingly abundant. By June 12 puparia were found in large numbers, and all the cauliflower of many market gardeners was reported destroyed. By July 7 maggots were transformed to pupæ. September 26 was the latest date at which flies emerged from puparia in the laboratory.

On July 2 several cabbage maggot flies which had been confined under a bell jar with a potted cauliflower plant laid fertilized eggs, which hatched on July 6, a few hours over three days from the time of laying. The eggs were laid on the soil near the plant. The same observation was repeated with other specimens, the flies in the latter instances laying within four hours of the time they were confined and frequently placing their eggs in the axils of the leaves.

The hatching of two eggs was observed. In each case the larva appeared to emerge from the egg through the groove on the side. One egg was observed to hatch under the microscope, the active larva trying unsuccessfully for several hours to free itself from the shell, and finally dying. The smooth surface of the glass may have been, and probably was the cause of its failure to extricate itself from the egg. Two other eggs, which were placed under observation immediately after being laid, hatched in five days from the time of laying. Another egg hatched in three days and five hours. Evidently the egg stage lasts from three to five days. The two eggs referred to as hatching in five days had been considerably shaken in a vial in being transported from the field to the laboratory; hence disturbing the egg evidently does not necessarily prevent hatching. The larvæ, judging from observations made this season, evidently require twenty to twenty-one days, under ordinary conditions, to reach maturity.

A lot of maggots which changed to pupæ June 6 emerged as flies June 19 and 20. Evidently, then, the pupal stage in Minnesota may have from thirteen to fifteen days' duration.

We are losing faith in the use of carbolic emulsion as employed against this pest, and believe that cultural methods may possibly prove our best means of control. Young maggots lived in the laboratory for two hours and twenty minutes immersed in carbolic emulsion, 1 part to 30 parts of water, and adult maggots required three hours and forty minutes' immersion before dying. Some eggs hatched after thirty seconds' treatment in carbolic emulsion at the same strength. On the other hand, good results were obtained by immersing the roots in hellebore and water at time of setting, using 1 part of hellebore to 2 parts of hot water, allowing it to cool before being used. The plants were immersed deeply enough to coat the lower part of the stems and were immediately planted and made an excellent showing. Good results were also obtained, in a protective way, by the use of bran and glue and sawdust and glue, the sawdust being mixed with glue in the proportion of ½ pound of the former to 1 quart of the latter. The glue was not at all thick, but represented 2 pounds of hard glue in 1 gallon of water. When bran was used the proportions were the same. The mixture was rather more sloppy than good chicken feed. It was applied by hand about the base of the plant, put well up on the stem, the diameter of the mass where it came in contact with the ground being about 4 inches. One quart was sufficient for 15 plants. The stuff quickly hardened and, though it softened somewhat during summer rains, did not disintegrate. Plants so treated made an excellent showing. A man can treat 6 to 8 plants per minute. This treatment, of course, would not be practicable on a large acreage.

The small red mite *Trombidium scabrum* Say was observed to be extremely active in sucking the eggs of the Phorbia. On May 15 an assistant in the field reported this mite as very numerous, averaging about two to a plant, and occasionally four or five were observed about one plant. On this date a large number of eggs examined had evidently been sucked. Frequently there would not be a single good egg found around a plant, out of a lot of a dozen or more that had originally been laid there.

We have obtained from the burrow of a maggot a cynipid parasite, *Pseudeucœla gillettei* Ashm.; we have also bred from a puparium *Plectiscus* sp.—identified by the American Entomological Society, of Philadelphia. We have also included among the predaceous enemies of Phorbia the carabid beetles *Pterostichus coracinus* Newm., *P. lucublandus* Say, *Agonoderus pallipes* Fab., and *Amara impuncticollis* Say, since immediately after being brought in from the field these beetles fed ravenously upon the maggot. These species were present in large numbers in almost all of our cabbage fields, as were also *Heterothops fumigatus* Lec., *Lathrobium anale* Lec., and *Bembidium quadrimaculatum* L., although these three latter beetles were not actually observed to eat the maggot. Plants in sandy soil appeared to suffer more, everything else being equal, than those planted in heavy soil.

RECENT OBSERVATIONS ON THE USE OF HYDROCYANIC ACID GAS.

One sometimes has occasion in fumigating mills of small size to drop packages of cyanide into jars containing acid, and at such times the question as to how much time elapses between the dropping of the cyanide, inclosed in a double sack, and the giving off of the deadly gas is an important one. In doing the work personally I have allowed fifteen seconds as a conservative estimate in this direction and acted accordingly. To place this matter beyond any doubt, however, we have this fall made several trials, timing the interval between the dropping of the double bag of cyanide into the jar and the first appearance of the fumes, with surprising results. A double manila sack was used in each case—that is, one sack inside another—and various makes of sacks. In each case the liquid was fairly warm, but no observation was made on its exact temperature. We found in a series of trials that this interval varies from twenty-nine seconds, the lowest period, to four minutes, the latter being the highest interval, the variation evidently being largely due to variations in the thickness and character of the paper of which the sacks are made. Of course a variation in the warmth of the liquid would cause a difference. Further experiments, bringing in the temperature factor, are planned for next summer. The experiments cited herewith were performed late in the fall, and the steam caused by the union of the acid and water did not cease until the liquid was fairly cool.

In connection with these experiments the question arose, " Is it not possible that fumes which would be fatal, if breathed, rise from the jar before they are visible?" This was answered in the negative by placing a live guinea pig in a wire cage about 6 inches above the top of the jar immediately after the charge of cyanide had been lowered into the acid. Visible fumes began to rise two minutes after placing the charge, and a few seconds later the guinea pig succumbed, showing that the dangerous gas was not given off in a fatal amount until fumes were observed. It would seem, then, from these results, that, on a very conservative estimate, one can depend upon at least twenty seconds when double sacks are used, and much can be done in that time.

Another important question connected with the use of hydrocyanic acid gas is the distance it will penetrate into a semisolid mass—a sack of bran, for instance—or masses of cereals held together by the webbing made by the flour-moth larvæ. An apparatus used by this Department to ascertain this was found to be faulty too late in the year to remedy the defect, and the results of that particular experiment, therefore, can not be relied on. However, the matter was given a practical test by exposing a mass of webbing over 2 inches thick, containing live worms, pupæ (and probably eggs) of the flour moth to the fumes of the gas as commonly used at the above strength, for over ten hours, the time commonly occupied in a fumigation. As far as could be observed at the time, everything in this mass was killed, and after three months' observation of the same in our laboratory no sign of the flour moth in any stage was apparent, indicating, possibly, that this gas has a greater penetration than we had supposed. At the same time, this isolated experiment should not be relied on as certifying absolutely upon this point.

WORK AGAINST THE LITTLE RED ANT IN A RESIDENCE.

The little red ant (*Monomorium pharaonis* L.) has been a great pest in a large residence in Minneapolis for several years past. During the fall of 1905 these ants became so numerous that we were requested to try to eradicate them. At that time very few parts of the house seemed to be entirely free from the pests. Flowers, food, or candy left in almost any part of the house would be covered in a few hours. The ants were particularly annoying when they were found in the pantries and kitchen, getting on food just before it was taken into the dining room.

Clusters of cocoons were located in the walls of the furnace room in the basement, this room being directly beneath the kitchen and pantries. At first carbon bisulphid was used with good results, the liquid being forced into crevices in the walls where the ants were observed, but the gas penetrated to all parts of the house and was particularly disagreeable to the members of the household. As far as could be observed these "nests" were never placed very deeply within the wall, and consequently when we had to resort to kerosene we found this liquid to be just as effective as was the carbon bisulphid. This was applied with a syringe. The ants that were out of the "nests" at the time of applying the liquid would, upon their return, seek another crevice, and would soon found a new colony; then these new colonies would be located and saturated with kerosene. Finally, in January or February, 1906, no ants were seen about the house; they had completely disappeared, and we were confident that they had all been destroyed. In the fall of 1906, however, they became very numerous again, and our attacks against them with kerosene were renewed. Several nests were found in practically the same places as in the previous year, but the most persistent colony was found, seemingly, in the chimney. The nest itself, however, was never seen. The extermination of the ants in this location was extremely difficult, but at the time of writing their numbers appear much lessened.

Many so-called "ant cures" were tried, such as "ant sugar," pennyroyal, and tartaric acid solution made according to the formula given on page 97 of Bulletin 30 of the Division of Entomology, U. S. Department of Agriculture, viz, tartaric acid, 10 grams; sugar, 100 grams; water, 1,000 grams. None of these remedies was effective.

We had planned during the winter, when the house was to be unoccupied, to fumigate with hydrocyanic acid gas, but on or about December 22 every ant had disappeared, and we are now awaiting their reappearance before taking active measures against them.

It was decided to make the discussion on this paper and the president's address the first order of business for the afternoon session.

On motion the following committees were appointed by the president:

Nominations: Messrs. Marlatt, Osborn, and Webster.
Resolutions: Messrs. Fletcher, Slingerland, and Sanderson.
Membership: Messrs. W. D. Hunter, Summers, and J. B. Smith.

AFTERNOON SESSION, FRIDAY, DECEMBER 28, 1906.

The meeting was opened with a discussion of the presidential address and of the paper presented by Mr. Washburn. In reply to an inquiry concerning the effect of fumigation on insects attacking grain, Mr. Kirkland stated that he had used hydrocyanic acid gas in fumigating a mill, and had secured excellent results. One hundred and twenty-five pounds of cyanide were used, and as the building was not very tight this was applied at the rate of 1 ounce of cyanide to 80 cubic feet of space, and the building was kept closed for six hours.

A discussion then followed on the use of arsenate of lead. Mr. Frost stated that shade trees of average size could be sprayed with this poison for from 40 to 60 cents each, and that in woodland areas the price could be reduced to from 25 to 40 cents per tree. Such treatment is applied in regions infested with the gipsy moth, and thousands of trees are being sprayed with this poison. In reply to a question by Mr. Slingerland he stated that arsenate of lead does not burn the foliage to any appreciable extent if it is properly prepared. Men in his employ used 14 tons of this poison during the past summer, and in such large lots it was secured at from 11 to 12 cents per pound. He did not consider it advisable to attempt its manufacture when good material could be bought at this price.

Mr. Britton remarked that his experience in Connecticut had led him to believe that peach and Japanese plum trees could not be sprayed while in foliage without causing injury.

Mr. Kirkland stated that in manufacturing arsenate of lead it was necessary to form the precipitate in large vats, and if made in this way there would be very slight chance of foliage injury. In some cases, however, delicate leaves might be burned.

Mr. Marlatt inquired if the yellow acetate of lead was as good as the white acetate for making arsenate of lead, and Mr. Kirkland replied that the arsenate of soda which is imported carries about 70 per cent As_2O_5 and could be bought at New York, duty paid, for about 8 cents per pound. This year white arsenic is selling for 8 to 9 cents a pound. The 50 per cent grade of arsenate of soda is made by fusing white arsenic and soda together. Acetate of lead is sold in different grades—known as crystallized, white granulated, brown, and dark brown. The best manufacturers of arsenate of lead use white granulated acetate of lead.

Mr. Burgess stated that he had observed considerable injury from using homemade arsenate of lead, and in several cases this proved to be due to the fact that the arsenate of soda had been adulterated with salt. In one case an analysis showed that the sample contained over 25 per cent of salt.

President Kirkland announced that Mr. Orlando Harrison, of Berlin, Md., president of the American Association of Nurserymen, Prof. John Craig, of Ithaca, N. Y., and Mr. Emory Albertson, of Bridgeport, Ind., representing the American Association of Nurserymen, were present on invitation of the Association of Economic Entomologists, as the former association was vitally interested in the report about to be read.

On motion of Mr. Sanderson these gentlemen were admitted to the privileges of the floor.

The report of the committee on national control of introduced insect pests was read by Mr. E. D. Sanderson, chairman.

REPORT OF COMMITTEE ON NATIONAL CONTROL OF INTRODUCED INSECT PESTS.

To the Association of Economic Entomologists:

Your committee, appointed at the last meeting of the association to consider the national control of introduced insect pests, beg to report as follows:

After preliminary correspondence the committee seemed to be generally agreed except upon the matter of uniformity of nursery inspection. A subcommittee, consisting of Messrs. Burgess, Forbes, and Gillette, was therefore appointed to consider this matter. This subcommittee met at Urbana, Ill., and, having had a large correspondence with inspection officials throughout the country, formulated a report which was presented to the full committee at a meeting held at Baton Rouge, La., November 14. This report is embodied in section C, below.

As instructed by the association at the meeting at Baton Rouge, your committee conferred with a similar committee of the Association of Horticultural Inspectors represented by Messrs. R. I. Smith, of Georgia, and S. A. Forbes, of Illinois, and with representatives of the National Nurserymen's Association, Messrs. Watrous, of Iowa, and Albertson, of Indiana. All present agreed upon the line of procedure outlined below. At the meeting of the Association of Horticultural Inspectors at Baton Rouge resolutions were adopted similar to those below, advocating that the Secretary of Agriculture be empowered to inspect all the imports for insects and plant diseases and that he be empowered to make regulations governing the certification and inspection of nursery stock for interstate commerce, and appointed their chairman, Dr. S. A. Forbes, to act as a member of a committee to be composed also of a representative of the Association of Economic Entomologists and a representative of the National Nurserymen's Association to push this legislation.

The committee would therefore suggest the following resolutions and procedure toward securing such legislation:

A. *Resolved*, That the Secretary of Agriculture should be empowered to inspect all imports and to make regulations governing importations liable to harbor insect pests and plant diseases, and that sufficient appropriation be made for this purpose.

B. That Congress should authorize the Secretary of Agriculture to proceed to exterminate or control imported insects or plant diseases or any insect previously native to a restricted locality, but which may become migratory and threaten the whole country, whenever, in his judgment, such action is practicable, and that an appropriation be made for this purpose as a reserve fund for emergency use against any such pest which may arise. Such legislation would give the Secretary of Agriculture similar authority against plant enemies as now exists for procedure against animal diseases by the Bureau of Animal Industry.

C. (1) That the Congress of the United States be asked to enact a law empowering the Secretary of Agriculture to make such regulations as may be deemed necessary in order to secure uniform methods of nursery inspection and certification of all nursery stock which passes into interstate commerce.

(2) That all State or Territorial officials in charge of nursery inspection be urged to accept these certificates at their face value and that in States where laws are now in force which will not allow the acceptance of such certificates, the inspection departments be requested to endeavor to secure such State legislation as will make this possible.

(3) That each State should make and enforce such regulations as its local authorities may deem necessary, but that they be made as similar to those of the United States Department of Agriculture as practicable.

D. Your committee suggests that the Association elect a representative to form a committee with a representative of the Association of Horticultural Inspectors and a representative of the American Nurserymen's Association to push this legislation before Congress, as in the judgment of your committee this is the best method available for securing its passage. We would also suggest that topics A and C, above, be combined in one proposed law; and that topic B, involving the control of introduced species, be embodied in another law; and that, if the passage of both measures be impracticable, efforts be concentrated upon the law involving the inspection of importations and the control of nursery stock for interstate trade, and that the other measure be pushed later.

Respectfully submitted.

E. D. SANDERSON, *Chairman.*
C. P. GILLETTE.
H. A. MORGAN.
A. F. BURGESS.
S. A. FORBES.

Mr. Harrison stated that the nursery interests were being severely injured on account of the diverse and sometimes unreasonable requirements made for shipping stock into different States. He declared that the better class of nurserymen welcomed thorough inspection, and that under no circumstances would they be willing to have this work discontinued, as they considered it a benefit to themselves and the trade. Any movement which would bring about more uniform regulations and requirements, so that as little confusion as possible would result to the nurseryman, was very desirable, and he heartily favored the report.

Professor Craig stated that he believed that the principle outlined in the report was correct and that if workable legislation could be secured it would greatly benefit the nursery interests. He urged the necessity of such action as would prevent unjust discrimination, and which would help the nurseryman who was striving to do an honorable business to secure the delivery of his stock without expensive and objectionable delay. He therefore heartily indorsed the report.

Mr. Albertson remarked that he agreed with the statements made by the previous speakers and believed that the report submitted by the committee was a step in the right direction. He also pointed out the fact that the entomologists and nurserymen were coming to a better understanding of the situation, and thanked the association for the courtesies extended to himself and the other representatives of the Nurserymen's Association.

Mr. Sanderson stated that the problem of bringing about uniform nursery inspection requirements was a large and difficult one and that it probably could not be solved in a single year. He felt, however, that the report of the committee indicated the most practical line of work to be taken up in this direction, and if the necessary legislation could be secured it would result in bringing about a condition that would be more satisfactory to nurserymen, horticulturists, and inspectors. The Association of Horticultural Inspectors had adopted a similar report at their annual meeting at Baton Rogue last month and had appointed a representative to act on the joint committee suggested in the report.

Mr. Marlatt said that Congressional action would be taken when the nurserymen of the country as a whole joined in a strong demand for it, and that a demand from this source would have great weight with Congress, especially with the indorsement of the official entomologists of the different States and the State horticultural inspectors. The remedy, therefore, lay largely in the hands of the nurserymen of the country, and without their united support relief could not be hoped for from Congress.

Mr. Burgess pointed out that for the first time in many years the entomologists interested in nursery inspection had, through a committee, proposed a definite scheme for handling the problem. Harmonious relations now exist with the nurserymen, and they and the inspectors appear to have come to an agreement as to the best measure to adopt. He expressed the hope that the entomologists would accept and adopt the report.

Mr. J. B. Smith stated that, although Congress might pass a National law, it would not be able to overrule the requirements or regulations of State officials, and that, this being the case, he could not see how the law would be enforced so that any great benefit would result.

Mr. Webster pointed out that if a National law had been passed years before when the matter was agitated, there would not now have been very many conflicting State laws to interfere with the work. In spite of this, he believed the adoption of the report would be a step in the right direction, and that it was not yet too late to take up and push forward the work that should have been done years ago.

Mr. Summers called attention to the fact that one of the reasons for stringent requirements in some States was the careless inspection of other State officials, and that if many of the State inspectors were satisfied that a high standard of inspection requirements was maintained, such as would be the case if it were under Government control, many State requirements would, undoubtedly, be modified in such a way as to simplify interstate shipments.

After further general remarks a vote was called for, and the report was unanimously adopted. On motion, the election of the representative of the association to serve on the joint committee was referred to the committee on nominations.

The following paper was presented:

A NEW ORIENTAL INSECT PEST (?) IN MASSACHUSETTS.

By H. T. FERNALD, *Amherst, Mass.*

[Withdrawn for publication elsewhere.]

A paper was read, as follows:

OCCURRENCE OF THE GIPSY MOTH IN CONNECTICUT.

By W. E. BRITTON, *New Haven, Conn.*

During the season of 1906 my attention has been partly occupied in attempting to control, and to exterminate if possible, a small gipsy moth (*Porthetria dispar* L.) colony in Stonington, Conn. Stonington is the southeast corner town of the State, joining Rhode Island, and having an area of nearly 75 square miles. The infested portion covers, so far as we know, only about 1 square mile just north of the village, in the south part of the town.

For several years we have expected that the gipsy moth would appear in Connecticut, and have been on the watch for it. It has been reported several times from different places, but in each case upon investigation some other species was found to be the cause of alarm. The first real gipsy moth was taken at Stonington, July 30, 1905, by Mr. Ernst Frensch, a local collector, who recognized the insect because he had seen it in Germany. He noticed two males flying about in an apple tree, and, on looking closer, saw a female resting on the bark of the trunk, and put her in his cyanide jar. He put the specimen away in his collection, and forgot all about it until during the winter, when I wrote to the entomologists of the State asking for cooperation in furnishing records of their rare captures for use in our lists of Connecticut insects. Mr. Frensch sent me a number of records, including that of *Porthetria dispar*. I made an appointment with him, and visited the place March 6. He showed me where he had captured the female, and called my attention to an egg mass on a Norway maple tree near by. He also showed me an egg mass which he had found on a small bush. Suspecting that these might be gipsy-moth eggs, he had, in order to make sure, cut off the abdomen of the female moth and, obtaining the eggs from her, compared them with those of the egg mass and concluded that they were identical. We inspected the region and found a number of egg masses in some low bushes near the velvet mill. This, as well as the place where Mr. Frensch found the adult moth, is near the railroad, and not far from the point where the spur track leading to the steamboat dock branches from the main track.

The next thing was to learn the extent of the infestation, or, in other words, the size of the infested area. We applied to Massachusetts for a trained scout, and through the kindness of Superintendent Kirkland we obtained the services of Mr. C. S. Mixter for two weeks. Mr. Mixter scouted nearly 5 square miles of territory, giving as his opinion that the infested territory had been well surrounded. The brush on about 5 acres of land around the pond by the velvet mill was cut and burned before May 1, the hatching time for the eggs. The egg masses found were destroyed by soaking them with creosote oil. Banding trees with burlap was commenced about the middle of May; only a few were banded at first, but the number was increased as fast as seemed desirable. We supposed, of course, that about all of the egg masses had been destroyed, but the number of caterpillars found showed that some had been overlooked, and during the summer we ran across a number of these old egg masses—more even than had previously been destroyed.

Most of the caterpillars were found on old apple trees, though cherry, quince, rose bushes, and red maple were infested. Many of the old apple trees had received no care for many years, if ever, and the tops were crowded with branches, some of which were dead, the bark was rough, and in many cases trees were hollow or had cavities caused by broken or rotting branches. All of these faults were serious hindrances to our work because they furnished hiding places out of our reach for the caterpillars, so that they would not go under the bands where we could find them. We therefore pruned and scraped many trees, and filled up the cavities with stone and cement. A few trees were sprayed with arsenate of lead, and sticky bands of "tree tanglefoot" were given a trial. In a few cases brush growing near stone walls was found infested. The brush was cut and the walls fired with fuel oil to kill any caterpillars that might be hiding in them.

We had men on the ground continuously from June 7 to September 1, and during the latter part of June and first half of July ten men were kept busy pruning, scraping, and banding trees, and destroying caterpillars. The bands were visited each day until after nearly all the caterpillars had pupated, when they were examined less frequently—perhaps every other day—and finally twice a week, until all had transformed. All trees infested with caterpillars or egg masses were marked, as is done in Massachusetts. A breeding cage was made on the grounds, and in it were reared a number of adults for exhibition and illustrative purposes. During August a gang of laborers was employed to cut and burn brush, and the hedgerows through some of the fields were cleaned up. We interviewed the selectmen, interested them in our work, and they cooperated by cutting all the brush along the highways through and for some distance beyond the infested district. This brush was burned by our men. In four places caterpillars transformed in the stone walls, and egg masses were laid there. The walls were overhauled, eggs destroyed, and the walls relaid. All work was suspended September 1 to enable us to make the annual inspection of nurseries. Since November 16 five men have been employed cutting and burning brush and scouting for egg masses.

It was necessary to do considerable educational work, and immediately Bulletin 153 was issued from the Connecticut Agricultural Experiment Station giving brief accounts of the gipsy and brown-tail moths. Two months later the annual report, containing a further account of the gipsy moth, was distributed. Figures and brief descriptions of the insect and its injuries were printed on cards 11 by 14 inches in size, and nearly 2,000 of these have been distributed to schools. A number of life history sets in Riker mounts have been placed in drug-store windows in Stonington, Mystic, Noank, Groton, and New London. An illustrated lecture was given at New Haven May 9 and at Stonington November 26; specimens have been shown and talks given about the insect in about a dozen meetings in various other parts of the State.

Scouting for egg masses was done in April at Mystic, Midway, New London, Plainfield, Danielson, Putnam, and Willimantic. Nearly all portions of the State are visited during the year by some member of the office force on the lookout for such things, but no gipsy moths have been found anywhere outside of Stonington.

Up to the present time the results obtained may be expressed by the statistics in the following table:

Egg masses laid in 1905:	
Number destroyed	29
Number hatched	36
Egg masses laid in 1906, number destroyed	47
Caterpillars destroyed	10,000
Pupæ destroyed	47
Number of trees banded, more than	1,300
Amount of money expended	$1,700

A word as to funds: A few hundred dollars only could be spared at that time from our State appropriation for insect work, and the

Connecticut board of agriculture kindly appropriated $2,000, to be used if needed, and Governor Roberts and his associates assured us that if after using this money at our disposal still more was needed to hold the pest in check it would be forthcoming. We called upon the board of agriculture for $800, and the remaining $900 has come from our own insect-pest appropriation. An attempt will be made to have the State legislature, which soon convenes, set aside a few thousand dollars to be used if needed in work against the gipsy and brown-tail moths. The brown-tail moth has not yet been found in Connecticut, though it must be very near its borders in Massachusetts. We shall endeavor to exterminate the gipsy-moth colony at Stonington, and this can be done if it has not spread beyond the area where we have found it. The village of Stonington is on a narrow point of land extending into the ocean. The infested territory extends from the village northward and slightly eastward; it is flanked on both sides by water—on the east by the Wequetequock River and on the west by an arm of the sea extending northward from Stonington Harbor. A line from the northernmost extremity of this salt water extending easterly to Wequetequock River cuts the mainland some distance north of where any caterpillars or egg masses have been found, although considerable scouting has been done in this section and many of the trees were banded in caterpillar time.

Two natural enemies of the gipsy moth have been observed in Connecticut. The "caterpillar hunter" or "searcher" (*Calosoma scrutator* Fab.) was quite common under the bands, and one of these in captivity devoured gipsy moth caterpillars with avidity. Out of the ten thousand or more caterpillars gathered and destroyed four diseased ones were observed. These shriveled and finally died, as if attacked by some bacterial disease. While in Massachusetts the last week in June I observed the same or a similar disease which killed many caterpillars, though of course only a small proportion. Dr. G. E. Stone, botanist of the Massachusetts experiment station at Amherst, was investigating the matter, and I sent him two of the diseased caterpillars from Stonington. At that time he was not ready to report on the nature of the disease, but stated that a number of different organisms had been isolated from the diseased caterpillars.

Just how the pest reached Stonington may perhaps never be known, but there is much speculation regarding it. Eggs or pupæ may have been brought on packing boxes to the velvet mill or upon freight cars left upon the spur track. Certainly the worst infestation was near the velvet mill and the railroad, and I feel that it must have reached Stonington on steam cars via the New York, New Haven and Hartford Railroad. Some think that it may have been a direct importation from Europe, as Germans live in the locality, work in the mill, and occasionally travel back and forth.

At the present time it is difficult to find egg masses or, except for the marked trees and the cutting of brush, any other indications that the area is infested by the gipsy moth. But the work must be kept up even after it is believed that the last one has been destroyed.

In reply to a question Mr. Britton stated that the chances for exterminating this insect in Connecticut appeared to be good, that the people were interested in the matter, and an urgent appeal would be made to the State legislature for funds to use in suppressing the moth.

A paper was read, entitled:

NOTES ON FUMIGATION AND DIPPING OF NURSERY TREES.

By T. B. Symons and A. B. Gahan, *College Park, Md.*

[Withdrawn for publication elsewhere.]

Considerable interest was drawn to this paper, owing to the fact that the State of Oregon has recently required that nursery trees be dipped in the lime and sulphur wash rather than fumigated before they are planted.

Mr. Slingerland called attention to the fact that a temperature of 180° F. used in one series of the dipping experiments, was unnecessarily high, and this probably accounted for the serious injury to the trees.

Mr. J. L. Phillips stated that he had dipped one-year apple trees in cold lime-sulphur wash in the spring of 1906, as follows: 235 Black Twig, 205 York Imperial, and 20 Albemarle Pippin. The trees were dug, the tops cut off to within 3 feet of the crowns, and the tops dipped to the crowns in the wash, made by using 15 pounds of lime, 15 pounds of sulphur, and 5 pounds of salt to 50 gallons of water. The trees were immediately set in the orchard and all lived and grew well except one. The results with peach trees were not so good. They were cut back to within 2 feet of the crown and dipped as follows: 151 Smock, of which 124 lived; 142 Elberta, of which 76 lived; and 80 Salway, of which 66 lived. Many of the peach trees that lived died back a few inches from the top. As this was a commercial plantation, no checks were planted. There was considerable injury to both peach and apple trees in the experimental dipping tests, but the conditions under which the trees were handled may be partly at fault, as a number of untreated trees planted at the same time died also.

In reply to several questions, Mr. Symons stated that the lowest temperature used in the dipping experiments was such that a person could bear his hand in the solution. He could not say definitely whether all the trees were dug in the spring, but believed this was the case. No observations could be made as to whether this treatment killed the scale, as nearly all the treated trees died during the summer.

In the absence of Mr. Schoene, the following paper was read by Mr. Parrott:

THE WILLOW BORER AS A NURSERY PEST.

(*Cryptorhynchus lapathi* L.)

By W. J. SCHOENE, *Geneva, N. Y.*

The willows and poplars along the streams and canals, ornamental willows in the cities, and poplars and willows in the nursery are being seriously injured by this beetle. The first noticeable outbreak of the insect in this State occurred in a nursery at Rochester in 1902, and this species is now a serious pest in various parts of the State. In many poplar and willow plantations the beetle has been estimated to destroy 10 per cent of the stock and in some instances the entire plantation has been ruined. The species of willow and poplar that have been observed to sustain conspicuous injuries are: *Populus monilifera*, *Salix lucida*, *S. caprea*, *S. cordata*, *S. sericea*, *S. alba*, and *S. amygdaloides*.

This insect has been discussed in a comprehensive manner by Prof. F. M. Webster in a paper entitled "The Imported Willow and Poplar Curculio," which was presented before the Columbus Horticultural Society. This treatise also contains some observations made by Mr. A. H. Kirkland on the life history of the beetle and its destructiveness in Massachusetts.

The increasing importance of this species to the nursery interests of New York prompted an investigation to determine its life history in this State for the purpose of ascertaining a practical method for the control of the pest in poplar plantations. The aim of this paper is to call attention to the results that have been attained.

To understand clearly the trend of the work it is well at this time to review in brief the life history of this insect. Oviposition commences about August 1 and lasts through September. The eggs hatch in eighteen to twenty-one days, and the larva upon hatching begins to bore in the cambium layer, where it finds subsistence. As it approaches maturity it makes a channel in the heartwood. The larvæ commence to pupate about July 1 and the beetles begin to emerge two weeks later. For the next ten weeks the adults can be found in abundance. Before beginning to deposit eggs the beetles feed for a week or ten days on the bark of one-year shoots, after which they are more often found upon the older parts of the tree, especially in the injured portions of the bark and corky overgrowths caused by pruning. It is because of the large number of punctures on the young wood that the work of the adult is especially noticeable. This habit at once suggested the possibility of using arsenical sprays as a means of control, and to test the value of these poisons some experiments were made, as follows:

A young poplar in a nursery row was headed back and sprayed with poison; a bag of mosquito netting was then put over the tree to inclose some beetles. As a check to each tree treated in this way, beetles were confined in a similar manner as mentioned above upon trees that had not been sprayed. With one exception this work was done upon nursery poplars that were 2 to 4 years old.

It is not necessary to give the data in detail, but it is sufficient to say that the results of a number of experiments made during the fall of 1905 indicated strongly the possibility of using arsenical sprays as a remedy. When beetles were confined upon trees sprayed with poison they died in a few days, while beetles confined in a similar manner upon unsprayed trees continued to feed and to oviposit.

In order to corroborate these results the work was continued during 1906. In addition, an effort was made to determine the length of time that the spray was effective and whether or not the poison acted as a repellent. The experiments were conducted in the same manner as in the previous year and the results were even more conclusive. The poison was found to be effective for thirty days, and by close observation it was found that the beetles, when feeding, failed to discriminate between sprayed and unsprayed bark.

While the experiments were conducted according to laboratory methods and the number of beetles involved was limited to about three hundred, the results are encouraging and indicate that thorough spraying of poplar plantations with an arsenical poison materially reduced the number of beetles and thereby lessened the number of eggs deposited in the trees.

Experiments are now under way in commercial poplar blocks to determine the value of this treatment. From the work that has been accomplished it is estimated that an application of an arsenical poison to nursery poplars will cost about one-fourth of a cent per tree for labor and poison.

Mr. J. B. Smith stated that this insect was not a nursery pest, although it was present in New Jersey.

In reply to a question, Mr. Parrott said that the insect was found in western New York.

Mr. Slingerland related a case which had come under his observation where infested trees had been treated with pure kerosene and the borers had been destroyed.

Mr. Washburn remarked that nursery trees from New York badly infested with this insect had been shipped into Minnesota, and he thought that some requirements should be made to prevent such stock being transmitted.

Mr. Kirkland stated that the insect was common in Massachusetts and some of the nurseries were badly infested.

Professor Craig called attention to the fact that poplars were undesirable shade trees in the East, and raised the question as to whether this insect was not a blessing in disguise if it destroyed them. In the Northwest, where other trees would not grow, they were needed. In the East they should only be used for temporary planting; therefore it might be better to leave the growing of them to northwestern nurserymen.

Mr. Burgess remarked that poplars were undesirable shade trees, and that in East Cleveland, Ohio, where this borer had become established, and the San Jose and oyster-shell scales seriously attacked them, an ordinance had been passed prohibiting their planting.

The following paper was presented:

EFFECTS OF SPRAYS ON APHIS EGGS.

By H. E. Hodgkiss, *Geneva, N. Y.*

The apple aphides have been unusually abundant for several years in the orchards and nurseries of New York. The species represented are *Aphis mali* Fab., *Siphocoryne avenæ* Fab., and *Aphis malifoliæ* Fitch. The methods commonly used by our nurserymen in fighting the pests on apple blocks are, either dipping the stocks in oil emulsions or soapy solutions, or the direct application of these sprays to the foliage. In years when these pests are most abundant the treatment of the trees in this manner has not been entirely successful owing to belated applications and the protection derived by the insects from the curling of the leaves. As eggs on the nursery stock, especially the seedlings, have been numerous, and therefore quite conspicuous, nurserymen have often asked what would be the effects of contact sprays on eggs. As there was abundant opportunity for this work, experiments were conducted during the autumn and winter of 1904, 1905, and 1906 for the purpose of determining the comparative effects of different contact sprays upon aphis eggs.

For the purpose of the experiment, seedling apple stocks, upon which large numbers of eggs had been deposited, were selected. As it was necessary to have the conditions of the experiment under control, the trees, upon their removal from the nursery blocks, were grown in a greenhouse. The number of trees under observation was 322, and these divided into five lots. All the sprays were tested in each lot. The sprays employed were the sulphur washes, kerosene, kerosene emulsion, whale-oil soap, crude oil, Scalecide, Kil-o-Scale, Rex solution, whitewash, K-L mixture, kerosene-whitewash, and caustic soda. The number of eggs per tree was variable, but there were not less than 400 eggs on each tree, and the maximum number on one tree was 4,800. The total number of eggs by actual count in the experiment was 223,920, of which 158,885 were firm, while the rest were more or less shrunken. The trees were planted in boxes of convenient size, and during the treatment were isolated to prevent the applications from reaching other stocks. Each tree was examined daily, and as each egg hatched the aphis was killed and a record was made of the daily hatching of the eggs.

The results of the last two tests, which are representative, are as follows:

Fourth experiment: Less than 1 per cent of the eggs hatched on trees sprayed with the sulphur wash, crude oil, kerosene-whitewash, and Rex solution. The percentages of eggs that hatched on the trees receiving other sprays are as follows:

	Per cent.		Per cent.
Scalecide	8.9	Caustic soda	7.3
Kerosene	6.7	Kil-o-Scale	26.
Kerosene emulsion	7.6	Checks	22.4
Whale-oil soap	7.8		

Fifth experiment: No eggs hatched on the trees that received applications of kerosene-whitewash and whitewash. On the trees treated with the other sprays the following percentages of eggs hatched:

	Per cent.		Per cent.
Sulphur washes	3.5	Caustic soda	5
Scalecide	40	Kil-o-Scale	4
Kerosene	1.5	Crude oil	10
Kerosene emulsion	6	Rex solution	1
Whale-oil soap	9	Checks	31.4

Mr. Titus mentioned the fact that aphis eggs are often deposited in such a manner on the twigs that they overlap, and this being the case it would be difficult, and in some cases impossible, to cover all the eggs with the spray material. In making an accurate statement as to the percentage of eggs destroyed by spraying, this point and parasitism should be considered.

Mr. Hodgkiss replied that the small size of the trees enabled a most thorough application to be made in each and every case. The purpose of the experiment being entirely to test the advisability of spraying nursery stock, the question raised by Mr. Titus would in no way affect the results obtained. Replying to a question on the value of spraying these eggs he stated that the results show that spraying for the aphis in the egg stage is of doubtful utility, and the most effective work may be done soon after the aphides hatch.

A paper was read, entitled:

MANNER OF BIRTH OF THE WOOLLY APHIS OF THE APPLE (SCHIZONEURA LANIGERA HAUSM.) AND OF OTHER APHIDIDÆ.

By W. E. RUMSEY, *Morgantown, W. Va.*

The exact manner of birth of the agamic forms of the woolly aphis of the apple seems to be a disputed point; at least, there is a variance in the published records that I have been able to find on the subject. In a study of this insect, now under way at the West Virginia Agricultural Experiment Station, some additional facts have been obtained along this line which may be of interest.

In the Eighth Report on the Noxious and Beneficial Insects of Illinois, by Dr. Cyrus Thomas, is a statement relating to the reproduction of this species, which says:

> In so far as the method of propagation is concerned it has been shown by Dr. W. M. Smith, of New York, that it differs slightly from the true aphides, in that the young larvæ produced by the agamic females are inclosed in the thin egg-shaped covering heretofore mentioned, from which they have to free themselves in a manner analogous to hatching. The remains of this covering may often be seen attached to the tip of the abdomen, and is doubtless the supposed cottony secretion alluded to by Doctor Fitch in his description of the young larva.

A view diametrically opposed to that given by Doctor Thomas is found in the Report of the Department of Agriculture for 1879, where this insect is treated, and from which the following extract is taken:

> Mr. Howard has repeatedly watched the birth of the young of the wingless agamic females and positively states that they are born without the enveloping pellicle or pseudovum. While the head and its appendages were still within the mother, he has seen the legs kicking vigorously outside.

These conflicting statements have led me to make careful observations along this line. While a student at Cornell, my study of this species seemed to corroborate the views of Dr. W. M. Smith. During my present study of the woolly aphis a large number of births have been carefully watched, which has added materially to the evidence sought.

To see the entire operation of birth satisfactorily it was necessary to devise some method by which the mother could be held in the position desired. To accomplish this a rectangular cell was made on a microscope slide with four small pieces of another slide. The cell was just wide enough to hold a mature insect when placed on its side, but of sufficient length to allow free extrusion of the young. The pieces of glass were held in position with Canada balsam, and a cover glass was placed on top to prevent the escape of the insect. All observations of birth in this cell were made under a microscope, using a two-thirds or one-fourth inch objective.

The manner of birth, as repeatedly observed by me, is as follows: First there is a contorted movement of the abdomen of the mother, which is immediately followed by the appearance of the young aphis as an egg-like object at the anal opening. In about thirty seconds the body of the young is forced out until the eyes appear, when the movement is checked, then ceases entirely, with the mother retaining a hold on the crown of the head. At this time the dark spots that mark the eyes are the only means by which the object might at first be distinguished from an egg. The antennæ, together with the legs, are bent toward the tip of the abdomen and held closely against the ventral surface by a transparent membranous sac. This sac soon breaks at the crown of the head and is worked backward (caudad) by a continuous expansion and contraction of the body, accompanied by an interrupted pulling and pushing movement of the antennæ and legs. These motions are similar to those of an insect working its way out of a pupa case. The progress of the membrane as it moves backward (caudad) is at first indicated only by the hairs at the base of the antennæ and on the head springing into an erect position as they are freed. In from three to five minutes after the membrane begins moving off, the antennæ are liberated, and a small amount of whitish substance appears at the tip of the abdomen. Each pair of legs is then liberated in turn. As the sac works farther back its ragged edge becomes visible and the shriveled membrane at the tip of the abdomen increases in quantity. The last pair of legs is freed in from three to seven minutes after birth. As soon as the legs are freed they begin to kick vigorously, the kicking continuing from one to two minutes after the last pair is liberated; whereupon the mother lowers her abdomen and presses her offspring down, seemingly with the intention of assisting it in getting a firm footing, and at once loosens her hold. After the young is on its feet, the cast pellicle adheres to the tip of the abdomen for about two minutes, when it is worked off, leaving the insect smooth and glistening, but not yet entirely free, for a waxy thread still connects the setæ of the beak with the discarded pellicle. After several tugs and pulls the thread is broken and the insect crawls away.

Many times I have loosened the young insect from its mother, while she was holding it by the crown of its head, and carefully watched its subsequent movements. Only a slight touch with a camel's hair brush is necessary to break this hold. The motions of the body of the young and the freeing of antennæ and legs were identical to those already described, but in many such cases the young aphis died before freeing itself from the sac. This was probably due to the fact that the insect lay upon a miscroscope slide instead of being held aloof from the bark, as under normal conditions.

How are other species of Aphididæ born? In an attempt to answer this question I have made observations on several species, among which is the apple aphis (*Aphis mali* Fab.), which will be considered at some length. The birth of this species is similar in all the stages to that of the woolly aphis, except in one or two minor points. The legs, at least the last pair, are bent back upon themselves, so as not to extend beyond the abdomen, while being pressed to the ventral surface by the pellicle. When the young has all its legs free from the sac the mother does not in all cases, as observed with the woolly aphis, press her offspring down for a footing, but simply loosens her hold. Apparently the greater length of legs in this species makes it unnecessary for the mother to assist her young in this way. As soon as the young begin to free their antennæ and legs a delicate whitish substance appears on the tip of the abdomen, as with the other species described. The so-called honey tubes of the apple aphis, and kindred species, are bent toward the extremity of the abdomen and held closely against the body of the insect by the enveloping pellicle. As the edge of this membrane passes along over these tubes they bow up, and when the tips are released they straighten into nearly their normal position. Before the final release of the tubes the delicate transparent membrane, constituting the pellicle, can be readily seen stretched across the intervening space. Owing to the relatively much shorter beak of the apple aphis than that of the woolly aphis, I have not been able to see the waxy, thread-like connection between the setæ and the cast pellicle. If present, the separation probably takes place when the last pair of legs is being liberated, which would tend to prevent a view of the thread. When the legs of the apple aphis are free, the discarded pellicle adheres to the tip of the abdomen for a short time, whereupon it is worked off by the movements already described. In one instance, however, I distinctly saw a young aphis deliberately remove the shriveled pellicle from the tip of its abdomen with its hind legs.

In all the other species of Aphididæ which have been under consideration the manner of birth, in every case, was similar to that of those already described.

Mr. Quaintance remarked that his observations as to the mode of birth of aphides agreed with those of the speaker. He called attention to the fact of recent statements in literature to the effect that the so-called honeydew of aphides was excreted only from the anus, the idea that some was secreted also from the cornicles being erroneous. He asked for observations of the members present on this point.

In reply to a question by Mr. Slingerland as to the number of aphides whose birth had been observed, Mr. Rumsey stated that he had watched the manner of birth of probably fifty individuals. He also stated that he had never seen honeydew secreted from the honey tubes, but always from the anus of the aphides.

Four papers were then presented, and discussed at the close of the last paper.

UNUSUAL INSECT HAPPENINGS IN NEW JERSEY IN 1906.

By JOHN B. SMITH, *New Brunswick, N. J.*

The summer of 1906 in New Jersey was remarkable for continuous rains during the middle of the season, favoring the development of some crops and insects and interfering seriously with others.

It seems contradictory to include the failure of the periodical cicada (*Tibicen septendecim* L.) to appear in New Jersey as scheduled as a "happening," yet it deserves to be recorded as such. In 1889 there had been no definite New Jersey localities for what was then known as Brood VIII; but in that year I secured four, at such points as to indicate a diagonal line of occurrence from the Palisades southwest to the Delaware a little south of Camden. The insect was nowhere very common and I doubted its reappearance in 1906. To cover the ground as thoroughly as possible I asked every correspondent of the office along this line to communicate with me, asked the members of the Newark, New York, and Philadelphia entomological societies to keep a lookout for specimens and records, and instructed Mr. E. L. Dickerson, one of my assistants, to cover the most likely area of appearance personally, besides keeping an open eye for "signs" in the course of his orchard and nursery inspection work. Mr. Dickerson was also asked to verify reports that were received, and this proved a wise precaution, since at least three records, apparently safe and in the proper localities, proved on investigation to be based on error. Not a single definite record did I get for New Jersey. Mr. Marlatt was good enough to send me a record from Bergen County, his correspondent claiming to have seen two specimens and to have heard of others from several localities. This record has not been verified, but may easily be correct, although my own correspondents in that same region failed to find anything. In any case nothing but a fragment of the brood remains in the State.

Incidentally, my attention was drawn to the other cicada species in the State, especially after the publications of Osborn, Davis, and

Joutel. It was found that all the forms occurred in New Jersey. and that we had also yet another which was readily identified as the real *pruinosa* of Say, leaving the species heretofore identified as *pruinosa* without a name. Mr. Grossbeck has proposed the name *sayi* for this form. To make certain just which form Linné intended as *tibicen*, the original descriptions and figures were studied, and it seems entirely certain that the original *tibicen* is a totally distinct species from the one we have heretofore determined as such. For the species heretofore known as *tibicen* the term **linnei** is proposed.

Perhaps the most interesting feature now in progress is the steady increase in numbers of the rose-chafer (*Macrodactylus subspinosus* Fab.). When I first came into the State, seventeen years ago, a scourge was in progress that culminated in 1890 after a period of gradual rise, and I was told then that some sixteen to twenty years before there had been a similar trouble, followed by a series of years when little was seen of the insects. We have had our series of exempt years, and now for the four years last past the beetle has become increasingly abundant. In those same localities where it appeared as a pest sixteen to twenty years ago it is again a pest, but not yet quite as bad as it was in 1890. I anticipate another year of increase before the culmination is reached. As to the cause of the decrease I could find nothing. There were no apparent parasites; but the larvæ seemed simply to become less plentiful each year until little was seen of them. As to remedial measures practically no progress has been made. The insects are killed by arsenites, but, especially when they attack grape, the mischief is caused before the poison can do its work; to say nothing of the difficulty of getting a sufficient supply of it on the buds. I am advising our growers for the city market to bag the most valuable varieties and all others that it will pay to protect in that way. Bagging as a protection against rot has been entirely discarded in New Jersey in favor of spraying with the Bordeaux mixture.

The army worm (*Heliophila unipuncta* Haw.) has, for the first time in many years, appeared as a pest to field crops in a limited district in southern New Jersey. It was promptly dealt with and did very little harm, but the interesting feature was the practical absence of the tachinid parasites that usually attack so large a percentage of the caterpillars. Always on previous occasions I have found an injurious army with the seeds of its own destruction apparent, but in this case there was so little infestation that practically all the larvæ collected and placed in breeding cages in the laboratory came to maturity. It will be a matter of very great interest to watch developments in southern New Jersey in 1907. In this connection it might be said that some army-worm injury occurs almost every year on our cranberry bogs and that, occasionally, there is so great an increase as to result in actually stripping a section of bog.

The cottony maple scale (*Pulvinaria innumerabilis* Rathv.), which has been the theme of papers through many localities in the northwestern section of the State, reached its culmination in New Jersey in 1905, and in 1906 dropped out of sight completely in those places where it had been most abundant the year before. It was a curious repetition of an experience about eight years ago, although the agent of control this time was apparently different. Mr. E. L. Dickerson's paper covers that ground fully and it needs only a mere mention here.

The elm leaf-beetle (*Galerucella luteola* Müll.) also, after a period of two years during which no spraying was required at New Brunswick, has taken a new start, and in 1906 the unsprayed trees in parts of that city were almost completely defoliated. The trees on the campus of Rutgers College were protected with arsenate of lead, and I proved to my own satisfaction that the 12-cents-a-pound material made by one insecticide company was quite as effective and satisfactory in all respects as the 20-cent product of another company, while a 17-cent brand was inferior in arsenical content and was short weight besides. It should·be added here that the controlling agent in this case is a disease that attacks the pupæ if the weather at that period of development is damp. In 1904 it was only moist, and the disease was not very prevalent; in 1905 the weather was hot and dry, the beetles all developed normally, and I prepared for the danger that I felt certain would come in 1906. I was not at home during the pupation of the brood last summer, so can say nothing as to probabilities for 1907.

The common oyster-shell scale (*Lepidosaphes ulmi* L.) has developed possibilities as a serious pest and has proved quite difficult of control in the more southern parts of the State. One of the Burlington County apple growers declares it more dangerous and difficult to deal with than the San Jose scale. There are two broods of it in that section of New Jersey, and in one of the towns it has developed as a serious pest to shade trees, especially maples.

Away off in one part of southern New Jersey is a little section of land especially adapted to peach growing and where fine trees bear excellent crops of good quality. In this corner and nowhere else in the State the peach soft scale (*Eulecanium nigrofasciatum* Pergande) has established itself, and our effort now is to prevent its getting away from there. Fortunately the area is completely isolated, and there is little or no chance of a natural spread, while no trees are grown for sale anywhere in the infested territory. Few trees are badly enough injured as yet to induce the growers to consider active measures, and matters will probably become a great deal worse before they become much better.

The catalpa sphinx (*Ceratomia catalpæ* Bdv.) now covers about the entire State of New Jersey, positive records being absent from one county only. It always seems to be worse the second year of its appearance in a given locality, and it has been about as troublesome in nurseries as anywhere.

Another failure to establish the Chinese mantid (*Paratenodera sinensis* Sauss.) in New Jersey is to be recorded. A large number of egg masses were tied out in an ideal location on the southeastern slope of the Orange Mountains, and most of these fell a prey to field mice. It seems curious that the insects should do so well near Philadelphia and that they should fail so uniformly in all sections of New Jersey.

The Asiatic ladybird (*Chilocorus similis* Rossi) has not been found again, although the orchard in which the lots sent up from Georgia three years ago were freed still stands unsprayed—what is left of it.

Although not strictly entomological, mite infestation should be noted as among the most important happenings of the season. Trees and shrubs of the most diverse kinds were infested and a great deal of foliage was disfigured, if not seriously injured.

MISCELLANEOUS INSECT NOTES FROM MARYLAND FOR 1906.

By A. B. Gahan and G. P. Weldon, *College Park, Md.*

Present indications are that the fruit growers of Maryland may have another serious scale pest to contend with in the near future. We refer to the terrapin scale (*Eulecanium nigrofasciatum* Pergande). From different localities in Washington County have come three complaints of very serious injury to peach trees by this scale. All told, several hundred trees have been killed or badly damaged by it. The growers report that the lime-sulphur-salt treatment is not effective against this pest, it being no uncommon thing to see full-grown scales in midsummer with a coating of the spray mixture still adhering to their backs, but apparently none the worse for it.

A more or less careful study of the life history of the insect was made at the Station the past season, and it brought out the following facts: The scales pass the winter as immature females, finishing their growth in the spring. The eggs are deposited beneath the female scale, and are very numerous. Hatching begins about June 1 in our latitude, and crawling young may be found from that time until the second week in August. The young apparently all go to the leaves immediately after hatching, and there settle along the midribs and veins, where they remain for a period of from six to eight weeks. The males then emerge, winged, while the females migrate back to the twigs, settling along the under side of the twigs and branches. This migration of the females began about July 20, and by September

1 practically all were gone from the leaves. Copulation was not observed, but probably took place during the migratory period.

Two important parasites were noted, one a braconid, the other a fungous disease (probably *Cordyceps clavulata*). The fungus first made its appearance in the latter part of July, when a few individual scales on a single tree were noticed with a whitish discoloration about the edges. In a few days the discoloration had spread over the whole bodies of these insects and had also infested many others, both young and old. Within three weeks the disease attacked a majority of the insects on the five infested trees that were under observation. By the 1st of November it had apparently cleared four of the trees of the scale, while the fifth tree showed only occasional healthy specimens, and these were usually isolated on the tip of a twig. The very damp season no doubt accounts to some extent for the activity of the fungus.

A small brood of periodical cicadas (*Tibicen septendecim* L.) appeared in Washington County in July. They belonged to Marlatt's Brood XIV, and are confined to a very limited portion of the country, principally in the neighborhood of Mapleville. While quite numerous in that locality, the brood did very little damage, and its occurrence is important only as a matter of record.

Some observations were made to determine the life history of the codling moth (*Carpocapsa pomonella* L.) for the latitude of Maryland. About 75 per cent of the first brood of larvæ were found to enter the fruit at the calyx end. It was found by banding trees that the greater number of larvæ of the first brood reach maturity and pupate between June 20 and July 10, but that quite a considerable number do not leave the fruit until later, some first-brood larvæ being taken as late as August 10. Eggs from the first-brood moths were collected quite plentifully during July on both leaves and fruit. The majority of the second-brood larvæ were found to enter the fruit at other than the calyx end. The larvæ of this brood begin coming down about August 1, and the number collected from beneath the bands showed a constant increase from that time until August 25, when it began to decrease. A few larvæ collected during August pupated, but the great majority spun cocoons and remained as larvæ. Undoubtedly the few pupating individuals were belated first-brood larvæ. An interesting case of destruction of codling-moth larvæ as they were pupating, by a small red ant, which was not identified, was observed. Scarcely a collection of larvæ was made from the banded trees without finding several worms that were being devoured by the ants.

In November a report was received of injury to chestnut telephone poles by a flat-headed borer of some kind. Specimens of the borers and their work were secured and taken to the Bureau of Entomology,

U. S. Department of Agriculture, Washington, D. C., for identification, but Doctor Hopkins reported that he was unable to identify it even generically. The larvæ collected were about an inch in length, white, with the first three or four segments much broader than the remaining. They work below the surface of the ground in the sapwood of the pole, some penetrating an inch or more into the wood. The pole from which our specimens were collected was very badly infested, there being probably four dozen borers in it. The borers weakened it so much at the surface of the ground that it had to be removed. The infested butt has been secured and placed in the insectary in the hope that adult specimens of the insect may be secured.

NOTES ON INSECTS OF THE YEAR 1906 IN NEW YORK STATE.

By E. P. Felt, *Albany, N. Y.*

The leaf feeders, such as the yellow-necked apple-tree caterpillar (*Datana ministra* Dru.), the red-humped apple-tree caterpillar (*Schizura concinna* S. and A.), the hickory tussock moth (*Halisidota caryæ* Harr.), and the black walnut worm (*Datana integerrima* Grt. and Rob.), have received more attention than usual owing, probably, to the wide-spread interest which led many to keep a close watch for the possible occurrence of either the gipsy or brown-tail moths (*Porthetria dispar* L. and *Euproctis chrysorrhœa* L.). A placard, describing these two insects briefly and figuring them in colors, was distributed in many sections of the State where there was likelihood of the pests becoming established. It is gratifying to state that no undoubted evidence of even their casual occurrence in New York State was secured, despite newspaper statements to the contrary. Every report regarding these species was followed up and in each instance found to be based upon insufficient information. An occurrence out of the ordinary was the capture in Albany of a large South American moth (*Thysania zenobia* Cramer).

The scurfy scale (*Chionaspis furfura* Fitch) has continued abundant in the Hudson Valley, being especially numerous on young fruit trees in the vicinity of Annandale.

Experiments with the San Jose scale (*Aspidiotus perniciosus* Comst.) have been continued and the weight of evidence is decidedly in favor of employing a lime-sulphur wash, which, if properly prepared and thoroughly applied, gives fully as satisfactory results as any other preparation. Several experiments were conducted largely for the purpose of determining whether this wash could be further modified to advantage. A lime-sulphur wash was made in the normal manner, except that the ordinary local burnt lime was replaced by a finely prepared hydrated magnesium lime known as limoid, and the results were decidedly adverse to the employment of this material, despite its improved physical condition. The reaction between the limoid and the sulphur was not nearly so vigorous, even when hot water was employed. A sal-soda lime-sulphur wash was the subject of further tests and gave very satisfactory results. Oily preparations, known in a general way as "soluble" or miscible oils, have been used to some extent in the State. We have examined a number of trees treated with these materials and in each instance detected evidences of oil injury, though there was no doubt that, in some cases at least, a considerable proportion of the scale insects had been destroyed. It is impossible to say at present what would be the result of successive annual applications of such materials, though we would not be surprised were a considerable injury to develop with the advance of time.

The grape root-worm (*Fidia viticida* Walsh) continues abundant in the Chautauqua region, and during the past season has been exceptionally numerous in certain vineyards. It is an insect very local in its operations, and this fact renders it difficult to make any general statements. There is no question that it is becoming more abundant in certain vineyards here and there throughout the grape belt, and its numbers have increased materially the past year or two in the vineyards on the hills back from the lake. The grapevine or steely flea-beetle (*Haltica chalybea* Ill.) had an exceptional opportunity to injure grape buds, owing to the continued cold weather keeping the vines in check just as the foliage began to appear. The snowy tree-cricket or white flower cricket (*Œcanthus niveus* De G.) was so abundant in certain vineyards, where there was considerable weedy growth, as to injure many of the canes by depositing its eggs therein.

The sugar-maple borer (*Plagionotus speciosus* Say) continues to be a serious enemy of our sugar maples. An exceptionally interesting observation of the work of this insect was made in connection with a recent trip to Le Roy. Seven years before, namely, in September, 1899, we photographed a tree in that city which had been badly injured by this borer. The tree was about 18 inches in diameter and at the time of photographing was rather thrifty despite the fact that one side was completely girdled by the operations of the pest. The dead area at that time had commenced to enlarge and it was therefore not surprising, on examining this tree in November last, to find that the area of exposed wood had greatly increased. The original gallery was approximately 4 feet from the ground. At the present time the entire affected side, from the ground to 8 or 10 feet above, is dead, the bark has decayed or fallen away, and a large proportion of the magnificent limbs and branches on that side of the tree have disappeared. This illustrates in a striking manner the destructive nature of this insect's operations. It is very probable that an injury of this kind could be helped by bridge grafting, and it is presumable that extremely beneficial results would have been obtained even if this means had not been employed until two or three years after the initial injury, provided the bridge grafts were inserted in rather vigorous tissues.

The white-marked tussock moth (*Hemerocampa leucostigma* S. & A.) has been the cause of extensive injury the past season to shade trees in Buffalo, Lockport, Geneva, Rochester, Syracuse, Utica, Albany, Troy, and Brooklyn. They were so abundant in many of these places as nearly to defoliate a large number of trees. An extremely interesting phenomenon was observed in Capitol Park, Albany, July 5. Many of the trees were then badly infested by the tussock moth, some being almost entirely defoliated. On that morning the ground was thickly strewn with leaves and leaf-bearing twigs. Most of the latter bore from 3 to 5 or 6 leaves, and the cut end had invariably been completely girdled for a distance ranging from one-fourth inch to nearly an inch in length. This peculiar form of injury was first observed by the late Doctor Lintner in 1883, he having actually seen the caterpillar engaged in the girdling operations. Subsequently questions arose as to whether the depredator was correctly identified. It is gratifying to state that the trees in Capitol Park, mentioned above, were infested by practically no other insect. The tussock moth caterpillars were in several instances observed upon the fallen twigs, and there is, therefore, every reason to believe that this larva was the author of this somewhat anomalous injury. The girdling was limited, as was also observed by Doctor Lintner, to the new growth, and as the past summer has been exceptionally moist it is barely possible that there is some connection between a rapid, succulent growth and this form of injury, since it is only occasionally that the larvæ girdle the twigs as reported above.

The elm leaf-beetle (*Galerucella luteola* Müll.) has been abundant and injurious in certain sections, such as Oyster Bay, Ossining, Albany, Troy, Fort Edward, and Ithaca.

The false maple scale (*Phenacoccus acericola* King) appears to be establishing its claim as one of the most serious pests of the hard maple in New York State, since it has been injurious to trees in the vicinity of New York City in particular during the past four or five years. It was very abundant last summer at Port Chester, Middletown, and probably in other villages in the southern part of the State. The elm bark-scale (*Gossyparia spuria* Mod.) continues quite destructive, displaying a marked preference for the Scotch elm.

The violet gall midge (*Contarinia violicola* Coq.) is a very serious pest of the extensive violet-growing industry in and about Rhinebeck, N. Y. The crop in infested houses, according to estimates of growers, is reduced from one-third to one-half by the operations of this insect. Should this infestation become more general, the results might be exceedingly serious to the industry as a whole. An examination showed that the insect was distinctly local in its operations, since one-half of a house 150 feet long might be seriously injured, while the other half might be almost free from attack. Even in small houses there were distinct areas which suffered more severely than others, sometimes these being limited to only a square yard or two. The continued breeding of this species appears to be affected largely by temperature, since houses where the mercury was not kept below a certain point were decidedly more infested than others. The growers are almost unanimous in stating that when the temperature of a house can be kept down to 40° at night and does not rise to over 60° in the daytime there is little or no injury from the pest. The flies, according to growers, very rarely leave the plants, and can be observed only by flushing them with the hand. An examination was made in houses where there were flies and numerous larvæ on the plants, but none was to be found on the windows nor in the sheds at the ends of the houses, nor in cobwebs spun here and there about the structures. The insect displays a marked preference for recently opened leaves, apparently depositing its eggs in those which have just expanded fully; and, according to the growers, leaves perfectly straight one day may be badly curled the next. They note that leaves can be curled in a few hours, and are of the opinion that only a day or so elapses between the depositing of the egg and the curling of the leaves, an operation which protects the larvæ from most insecticides. Furthermore, several of them said that fumigating with hydrocyanic-acid gas apparently has no effect whatsoever in destroying the larvæ, though there is little doubt that the flies are killed. There is a marked periodicity in the appearance of the larvæ. Last summer they were first noticed in numbers early in July and then they became abundant again in August. Experience this year has shown that they may continue working in numbers even as late as the latter part of October. A number of infested leaves were placed on soil on the 12th, at which time no pupæ were manifest. The first adults appeared on the 22d and others emerged subsequently to the 26th, when about four were bred out. Another individual was obtained November 3 and lived to the 5th, at least. Owing to the fact that the plants could not be well cared for, it is probable that the period of the appearance of the flies was somewhat abridged by the unnatural conditions. The above data show that not over ten days is necessary from the time the larva forsakes the plant until the appearance of the perfect fly, and it may possibly be a little less. No pupæ were observed on the leaves, and there is no doubt that the insect normally undergoes its final transformations in the soil.

The periodical cicada (*Tibicen septendecim* L.) appeared in considerable numbers on Long Island during the past summer. The list of localities, compiled from various correspondents, is as follows: Wading River, Port Jefferson, St. James, Farmingville, Coram (on the road from Port Jefferson to Patchogue), Manorville, Eastport, East Moriches, Center Moriches, Commack, Brentwood, Cold Spring Harbor, Laurelton, Huntington, Oyster Bay, East Norwich, and Syosset. There is also a record of its appearance in very limited numbers on Staten Island.

THE PEAR BLISTER-MITE.

(*Eriophyes pyri* (Pgst.) Nal.)

By P. J. PARROTT, *Geneva, N. Y.*

This mite was undoubtedly introduced at an early period into the United States in foreign importations of nursery stock and was probably well distributed in many fruit-growing areas long before its presence was recognized. The first writer to direct attention to its appearance as an orchard pest in this country was Mr. Townend Glover,[a] Entomologist of U. S. Department of Agriculture, who in May, 1872, received specimens of its work from a correspondent. Under his direction Mr. Thomas Taylor, microscopist, examined some of the pear leaves covered with dark-brown blotches, which were said to be inhabited by myriads of small mites. The species was thought to be somewhat similar to the mite mentioned by Packard[b] as "*Typhlodromus pyri* of Scheuten," known to infest pear trees in Europe.

Before the meeting of the American Association for the Advancement of Science, held at Saratoga, N. Y., August, 1879, Dr. W. S. Barnard[c] presented a paper on "bud-blight insects," in which he attributed the brown and black blotches of pear leaves to the activities of mites. In 1880, Prof. T. J. Burrill[d] called attention to a widespread disease of pear leaves in Illinois and in the country at large, which was ascribed to the work of the mite *Phytoptus pyri* Scheuten. He mentioned the fact of the hibernation of the mites under the bud scales and the probable dissemination of these creatures in cions and buds. In succeeding years the work of this species was recognized in many States and was given widespread mention. In 1883[e] the mite was observed in large numbers upon imported Russian pear trees in experimental nurseries in Iowa, and by 1894 the mite was regarded as being generally distributed in the leading pear-growing States. The mite has attained its prominence in this country as an orchard pest because of its destructive work on pear foliage, and for this reason our literature upon the species is entirely concerned with the economy of the mite in its relationship to pear growing.

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[a] Report of U. S. Dept. of Agriculture, 1872, p. 113.

[b] Guide to the Study of Insects. By A. S. Packard. 1869.

[c] Scientific American, Dec., 1879, p. 3302.

[d] Gardener's Monthly, v. 22, 1880, pp. 18–19.

[e] Osborn, H., Iowa State Hort. Soc., 1883, pp. 127–135.

In recent years our attention has been called to the appearance of the mite in another rôle—as a pest of apple foliage. The mite has quite likely been active in this capacity for many years, but important injuries by it were not brought to our notice till 1902, when it was found to be very abundant in an apple orchard at Williamson, on Lake Ontario. In 1903 the infestation of these trees was much more conspicuous, and the strange appearance of the foliage attracted much attention from the fruit growers in attendance at the summer meeting of the State Fruit Growers' Association which was held in Geneva. Up to the present time its injurious numbers in this orchard have been maintained. During the same year Prof. M. V. Slingerland [a] observed, through the central portion of the State, numerous apple trees with many of their leaves showing the corky blisters characteristic of the work of this creature. The area in which the mite was present in conspicuous numbers has increased each year, and in 1905 marked infestation of many orchards in Wayne, Ontario, Monroe, and Niagara counties was noted. In his apple survey of Wayne County in 1903, Dr. G. F. Warren [b] recorded the presence of the mite in 53 orchards. It is stated that "the mites were not bad in more than one-half of a dozen orchards, but in a few orchards some trees had practically every leaf affected." A like survey of Orleans County [b] in 1904 showed somewhat similar conditions of apple trees with respect to this pest. Of 19 orchards showing mite injury, 4 were recorded as seriously infested, 4 considerably infested, and 11 slightly infested. During 1906 the work of the mite again attracted much attention among fruit growers, and in addition to the above counties the species was also present in large numbers in apple orchards in Livingston, Wyoming, Seneca, and Yates counties. The mite may be said to be common in our leading apple-growing sections in western New York, and its work upon apple leaves has also been recognized in Pennsylvania and Illinois.

The host plants of this mite, in addition to the apple and pear, are, as recorded by Dr. Alfred Nalepa, the service-berry (*Amelanchier vulgaris*), the common cotoneaster (*Cotoneaster vulgaris*), the wild service tree (*Sorbus terminalis*), the white bean tree (*Sorbus aria*), and the European mountain ash (*Sorbus aucuparia*).

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[a] Bul. 46, Bureau of Entomology, U. S. Dept. of Agriculture, 1904, p. 72.

[b] Cornell Bul. 226, 1905, p. 340; Bul. 229, 1905, p. 489.

The work of the mite on apple first shows on the upper surface of the leaf as distinct light-colored pimples, and on the underside as blisters or thickened areas of the same color as the leaf. The affected areas are of irregular size and are unevenly distributed, though the larger proportion of them are about the sides and the base of the leaf. Some of the blisters may have a reddish tinge, somewhat similar to the pear leaf-galls, but they are usually of a less brilliant color. As the galls become older they appear as corky spots of a reddish-brown color, and not black, as with the pear, which to the touch are very distinct from the healthy portions of the leaf. The individual galls average from one-twelfth to one-eighth of an inch in diameter and are usually oval or quadrangular in shape. Leading to the interior of each affected area there is usually one or more tiny openings. Often the spots coalesce, forming large irregular dead areas with smooth or slightly raised surfaces and of a dark-brown color, which rupture the leaves at the margins. About July 1 the most striking effects of the mites upon the leaves appear, especially if there is much yellowing of the foliage, as frequently occurs. Upon the upper surface of such leaves the mite-infested spots are of a light-brown or of a dark-green color and are uniformly brown beneath. These spots are usually thickly massed, forming a dark, broad band of irregular width along each side of the leaf, which contrasts conspicuously with the intervening light-yellow area about the main rib. The mites also cause pimples about the calyx cavity and on the stems of young apples. In several instances the work of the mites upon the leaves and fruit stems of the same cluster had so weakened the stems as to cause the falling of the fruit. Premature dropping of the apples by this means seems to be of rare occasion, and even on the worst-infested trees the loss of fruit is not appreciable. This seems incredible, as it does not seem possible that the foliage of the trees could be so completely overrun with mites without losses in crop production.

As has been stated by other observers, notably Prof. T. J. Burrill, in his study of the species on pear, the mites spend the winter in the buds, preferably under the second and third layers of the bud scales. As the buds burst there is a movement of the mites to the unfolding leaves, in which eggs are deposited. This migration takes place with the maturing of the bud scales, during the latter part of April and early May, depending on the season, soon after which the discoloration of the leaves by pale and red-colored spots occurs. On pear foliage the galls are largely grouped in a row on each side of the main rib, while on apple leaves the affected areas appear in the greatest numbers about the sides and the base of the leaf. This difference in the arrangement of the diseased spots on apple and pear foliage seems to be determined by the manner of the distribution of the pubescence of the leaves and the condition of the leaves when unfolding, which differ slightly with these two kinds of fruits. Mature mites may be found in the leaf tissues during the first week in May, and from then on into September eggs and larvæ are present in the galls of the leaves. During the latter part of May and first part of June the mites in greatly increased numbers may be found in the pubescence of the new wood and in the fruit and leaf stems and upon the unfolding leaves of the new growth. During October they largely abandon the leaves and swell the numbers already in hiding in the buds and in the pubescence of the bark of the new wood. Hibernation occurs under the bud scales and apparently none of the mites passes the winter in the pubescence or in crevices of the bark.

Treatment for the mite is much more difficult on apple than on pear trees, mainly due to the larger size of the trees and the greater abundance of the pubescence on the buds and the new wood. In our experience the crude and refined oils, either clear or emulsified, have proved the most efficient sprays. Because of its comparatively safe qualities and cheapness, kerosene emulsion diluted with 5 parts of water appears to be the most practicable remedy for the spraying of apple orchards when treatment is advisable, the applications being made either in the late fall or early spring before the buds swell.

In the study of the mites on apple and pear foliage four other species of Eriophyidæ have been recognized. These are *Eriophyes pyri*, var. *variolata* Nal., *Eriophyes malifoliæ* Parr., *Phyllocoptes schlechtendali* Nal., and *Epitrimerus piri* Nal. With the exception of the first named, these are vagabond species and seem to thrive on the underside of the leaves. *Phyllocoptes schlechtendali* and *Epitrimerus piri* are foreign species and appear to be more common here than on the Continent. The behavior of these two species in the future is a matter of much interest, as both, because of their large numbers, seem to show possibilities of developing to greater economic importance.

In discussing these papers, Mr. J. B. Smith brought out the fact that experiments were being conducted for the purpose of preparing arsenate of lead by the action of electricity on lead. Some good results had been secured, and the process, if perfected, promised to cheapen the price of this insecticide. He had tried arsenate of lead made by several manufacturers.

Mr. Kirkland stated that about 200 tons of arsenate of lead had been used the past season for fighting the gipsy and brown-tail moths. It was applied at the rate of 1 pound to 10 gallons of water, and no burning of the foliage was observed.

Mr. Quaintance called attention to some tests of various arsenicals on peach foliage made by the Bureau of Entomology during 1906, and stated that all arsenicals used—as arsenate of lead (homemade) and the principal proprietary brands, Paris green and Scheele's green—were injurious either to the foliage or fruit. A new insecticide arsenical was tested, namely, arsenic sulphid, which was stated by chemists to be quite insoluble. Nevertheless this proves to be more injurious than any of the other arsenicals used—in fact, killing several of the trees outright.

Mr. Webster recalled the fact that in 1888, while in Tasmania, he found the pear mite and also a species of fungus in connection with it. Dr. J. C. Arthur had told him that this fungus was always associated with this particular mite.

Mr. Parrott stated that the attack of these mites on foliage was sometimes mistaken for the pear scab fungus (*Venturia pirina* Aderh.).

Mr. Taylor remarked that arsenate of lead was being used to a considerable extent in Colorado. During the past year 16 carloads had been applied with good results. He had used it on peach trees for the twig borer (*Anarsia lineatella* Zell.) and found that it worked satisfactorily. It can be used on these trees if it carries no free arsenic. In some cases the branches had been killed by burning. This trouble is usually indicated by the appearance of purple spots on the young wood. The rainfall in this section is 7 inches per year, and this may have some bearing on the effect of poison on the foliage.

Mr. Slingerland called attention to the use of Scalecide and other miscible oils. He stated that in an orchard badly infested with *Aspidiotus perniciosus* that had come under his observation excellent results had been secured when scalecide was applied.

Mr. Burgess remarked that he had used Scalecide and Kil-o-scale on a badly infested apple orchard last spring. The manufacturer's directions required the mixing of 1 gallon of these materials to 20 gallons of water. Tests were made using 1 gallon to 9, 14, 19, and 24 gallons of water. Satisfactory results were secured when Kil-o-scale was used at the rate of 1 gallon to 14 gallons of water, but when Scalecide was used at the rate of 1 gallon to 9 gallons of water the San Jose scale was simply held in check.

Mr. J. B. Smith stated that the difference in these two substances was not very great, although the Kil-o-scale carried more sulphur and 5 per cent less actual petroleum.

A general discussion of the subject followed, which was participated in by Messrs. Brooks, Taylor, Slingerland, J. B. Smith, Fernald, Quaintance, Britton, and others. This brought out the fact that variable results had been secured with these substances, as far as killing the scale was concerned, but no injury to the trees was reported. It was considered advisable to use a stronger solution than the one recommended by the manufacturers.

Mr. Slingerland called attention to the fumigation of greenhouses for controlling the violet fly (*Contarinia violicola* Coq.). Some large violet growers had suffered severe loss from this insect. It had been found that less than one-half strength of cyanid, as often recommended, may destroy the foliage of violets. It therefore seemed quite necessary for some further tests to be made along this line.

Mr. Sherman gave some general notes from North Carolina, and stated that where Scalecide had been used at the rate of 1 gallon to 15 gallons of water in the fall, and lime and sulphur had been applied in the spring, good results had been secured. The fall armyworm (*Laphygma frugiperda* S. & A.) did considerable damage during the past season. Rose bugs (*Macrodactylus subspinosus* Fab.), although usually not an important pest, defoliated liquidambar trees over large areas.

Mr. Brooks stated that the larvæ of rose bugs are eaten by the short-tail shrew. He had observed this in West Virginia during the past season.

The meeting then adjourned until 10 a. m. Saturday.

MORNING SESSION, SATURDAY, DECEMBER 29, 1906.

The meeting was called to order by President Kirkland at 10 a. m., and the following paper was presented:

SOME OBSERVATIONS ON THE NATURAL CHECKS OF THE COTTONY MAPLE SCALE.

(*Pulvinaria innumerabilis* Rathv.)

By Edgar L. Dickerson, *New Brunswick, N. J.*

In the various accounts of the cottony maple scale (*Pulvinaria innumerabilis* Rathv.) several parasitic and predaceous enemies have been recorded as infesting this insect and aiding, to some extent at least, in keeping it in check. A notable incident is that mentioned by Dr. L. O. Howard in his account of this species, in which he states that, because of the parasite *Coccophagus lecanii* Fitch, "it was found almost impossible to carry the scale insect through the season at Washington in 1898." The forms acting as the most effective checks to the scale may differ in the various localities, and apparently even in the same locality at different periods. For example, it was stated that in Washington in 1879 the most effective enemy of this insect was the larva of *Dakruma coccidivora* Comst. Some of the enemies, however, appear to be found wherever the scale occurs, and prominent among these are the parasite *Coccophagus lecanii* Fitch and the coccinellid beetle *Hyperaspis signata* Oliv. and its larva. It has been due largely to these species that the scale has been controlled in New Jersey during the past two years.

In 1904 *Pulvinaria innumerabilis* was noted rather plentifully in several places in Newark and near-by towns and at New Brunswick, and the indications were that it would be much more plentiful the following season. Our anticipations were realized, and in 1905 the scale occurred more abundantly than it had for several years. In order to watch its development the infested districts were visited from time to time and the condition of the insects and the trees noted. As the year progressed it was observed that the enemies previously mentioned were materially and effectively checking the scale, and it was predicted that the number of the insects would be considerably reduced and in some localities nearly exterminated in 1906. These predictions were likewise fulfilled; and in Montclair, where some of the worst infested districts occurred in 1905, there has been very little evidence of the Pulvinaria during the past year.

The first signs of parasitism were observed in the middle of April, after the fertilized female scales had started to develop. While most of the insects at that time were becoming enlarged, a few were observed to be quite convex, and an examination showed that they were infested with parasitic larvæ, a few of which were full grown. Only a single larva occurred in each of the scales, which were light in color at this time, but as the larvæ pupated the parasitized scales became dark and hard. From this time on the number of the latter increased, and by the middle of May two and one-half times as many parasitized as good scales could be observed on some of the leaves.

The adult parasites were first observed about the middle of May and continued in increasing numbers until early June, after which they began to decrease, and were last observed about the middle of that month. Examples were sent to Dr. William H. Ashmead, who determined them as *Coccophagus lecanii* Fitch. Whether this parasite hibernates as a larva or in the egg stage I am unaware. It is apparent, however, that the larva begins to develop some time in early April, and the species continues in evidence for a couple of months. In emerging it cuts an irregularly rounded hole in the dorsal surface of the scale, and, so far as I could observe, it was always nearest the posterior end.

Thus the parasites had destroyed many of the hibernating females, but the number of the latter which went into hibernation was so large that, in spite of these parasites, there still remained a goodly number to oviposit and reproduce.

The egg masses began to develop early in June, and by the middle of the month many of them were apparently full sized. In Montclair, where the worst-infested district was observed, the insects were so abundant as to form continuous lines along the underside of many of the infested twigs and branches. An examination of the egg masses there and in other localities revealed the fact that some of them were infested by the larva of *Hyperaspis signata.*

This larva, because of the cottony-like waxy covering of the dorsal surface, is well protected among the egg masses, especially since it is often found feeding within the egg mass, when the latter may appear perfectly normal. Often only a single larva infests an egg mass; but sometimes more will be found, especially when they are young. On the other hand, a single larva may destroy a large proportion of the eggs in several masses.

On June 16, when the coccinellid larvæ were first observed at Montclair, a few of them were nearly, if not quite, full grown, while others were very small. From this time on their number increased until the early part of July, when they began to decrease. By June 28, in Montclair, scarcely an egg mass could be found which was not or had not been infested by them. The first pupæ were observed both in the laboratory and on the infested trees on June 24. A few of the larvæ at this time could be observed crawling on the trunks of the trees and getting beneath the loose bark, where the pupæ were found. The pupa is brown in color, but covered more or less with the white material from the cast larval skin. The earliest pupæ were found, as just stated, on the trunks of the trees under the loose bark and in the crevices, and it has been stated that the insect always goes to these places to pupate. But this is not the case, for most of the later pupæ were found within the eaten-out egg masses. The truth is that the insect desires to pupate in a protected situation, whether under the bark or elsewhere.

The first beetles to emerge in the laboratory were observed on July 7 and came from pupæ which had been in that stage for two weeks. It was about this time also that beetles were noted on the infested trees, and they continued in evidence until the early part of August, after which no more were observed. While the larva of the coccinellid fed on the eggs of the Pulvinaria, the beetle itself devoured the young scales which set on the leaves. The young scale adheres closely to the leaf, and it was interesting to watch the beetle in its efforts to secure it. If the latter was not too closely set the beetle would successfully pull it up and then rapidly devour it; but sometimes the scale was too securely fastened, and then the coccinellid, after making several futile attempts to get its mandible under the side of the scale, would finally give it up and attack another specimen.

The great number of scale insects destroyed by the coccinellid and its larva can only be realized when we consider the large number of eggs deposited by the Pulvinaria. At Montclair, where these insects and beetles were most numerous, between 500 and 1,000 young scales were counted on each of several leaves and there were many leaves just as badly infested; but after the coccinellid had completed its work not a leaf could be found with more than a dozen scales set on it, while most of the leaves showed still fewer.

In looking over the long series of beetles bred from larvæ it was found that there were some variations in both the males and females in size and markings. The majority of the specimens were black in color, with the single reddish spot on the disk of each elytron, but a few examples were found which showed an extra smaller red spot near the tip of each elytron. This latter is in all probability the form which was originally described by Olivier as *signata*, while the form with the reddish spots, which occurs most commonly, is the one Say described later as *binotata*. Olivier's name, therefore, has precedence and should be the one by which the species is designated.

It is interesting to note also that while in 1905 this species was found almost exclusively feeding on the Pulvinaria and only occasionally attacking *Pseudococcus aceris* Sign., just the opposite has been true the past season (1906). The insect has been found whereever *Pseudococcus aceris* occurred, but only in small numbers attacking the Pulvinaria. This is due in part perhaps to the fact that the latter insect has not been so abundant. Apparently the Pulvinaria is the favorite food of the coccinellid, but being unable to secure a sufficient amount of this, it attacks the Pseudococcus and other species.

Although the beetle and its larva did such effective work in Montclair in checking the scale, there were other places where it had not been so abundant, and consequently a much larger number of scales set and developed in those localities.

On July 24, when, at New Brunswick, I examined some leaves fairly well set with young Pulvinaria, I found that a few of them were parasitized and, except for their smaller size, appeared precisely like the parasitized forms of the hibernating females. Upon inspecting the infested trees in other localities I found that conditions were similar—a few examples parasitized in every case. An examination of the latter showed larvæ and pupæ similar to those of the parasite of the hibernating form. Within a day or two adults of the latter made their appearance both in the laboratory and out of doors; and except for their smaller size, being not more than one-half as large, they resembled very closely *Coccophagus lecanii*, the parasite of the hibernating scales.

From this time on the number of these insects increased and continued to appear until about the middle of September, after which very little was seen of them. Leaves collected August 11 showed 1 parasitized scale to 10 good ones, and leaves observed in September showed a still greater proportion. Two of the leaves carefully examined showed in one case 289 and in the other case 136 parasitized insects, and many of the leaves were in a similar condition. At Montclair, where the coccinellid had almost exterminated the Pulvinaria, the majority of the few remaining scale sets were parasitized. These insects bred and increased rapidly, and in all respects, except size, resembled *Coccophagus lecanii.*

Specimens were sent to Doctor Ashmead for examination, however, and he determined them as *Coccophagus flavoscutellum* Ashm. However this may be, I am strongly of the opinion that we have a single species which is dimorphic, the larger form determined as *lecanii* Fitch, bred from the larger hibernating female scales, and the smaller form, not more than half as large as the *lecanii* form, which may be the species described as *flavoscutellum* Ashm., bred from the smaller scales, the size of the parasite depending on the size of the host.

SUMMARY.

The trees were badly infested with *Pulvinaria innumerabilis* Rathv. in the winter of 1904–5. As the scales developed in the spring it became evident that they were infested with the parasite *Coccophagus lecanii* Fitch, which in some instances destroyed over two-thirds of the scales and continued in evidence until about the middle of June. By this time the egg masses of Pulvinaria were becoming large and conspicuous, and an examination revealed the fact that they were infested by the larva of *Hyperaspis signata* Oliv., which in some places, conspicuously at Montclair, destroyed nearly all the offspring of the scale, the coccinellid larvæ feeding on the eggs and the adult beetles destroying the scale sets. The coccinellid continued until the 1st of August, by which time the scale larvæ had all set and were becoming well developed. These young scales were parasitized like the hibernating females, and the parasites, which continued until the middle of September, were apparently a smaller form of the spring parasite. The result of these combined attacks has been that in some places the scale has been nearly exterminated and in all the infested localities its numbers are considerably reduced.

Two papers were then presented on codling-moth investigations, after which they were discussed.

REMARKS ON METHODS USED IN CODLING MOTH EXPERIMENTS.

By A. F. BURGESS, *Columbus, Ohio.*

In the great mass of data already published concerning the codling moth (*Carpocapsa pomonella* L.) it will be found that numerous standards have been used for determining the results of spraying. Many entomologists have followed the system of basing results simply on the number of picked apples which are wormy or sound on treated and check trees, while in other cases samples of one or more bushels of picked fruit, supposed to represent average conditions, have been counted and have served for making the determinations of the benefit derived. Sometimes an estimate of the wormy and sound dropped fruit has been made at the time of harvesting, but in the majority of cases no accurate account has been kept of the wormy fruit that dropped early in the season.

Undoubtedly this lack of data has been largely due to the fact that most entomologists who have attempted such experiments have not had at their disposal the necessary time to make complete counts of fruit. In some sections, also, horticulturists pay little attention to the fruit which drops early in the season, considering it a necessary evil when the crop is light and a direct benefit when the crop is heavy, as it saves labor in thinning. It would appear, however, if an accurate statement of the benefit derived by treatment is to be made, that all fruit growing on the trees should be accounted for.

In order to illustrate the case more fully, two tables are submitted, showing the percentages of benefit from spraying that may be deduced from the two different methods. Table I gives the treatment, in 1903, of two rows of 10 trees and 10 check trees in the orchard of Mr. R. L. Hudson, at Delaware, Ohio, with Disparene and Bordeaux mixture, also the number of wormy dropped apples, the wormy and sound picked fruit, and the percentages of sound fruit, using all the apples as a basis or by using only the picked fruit.

Table II gives similar data taken in the orchard of Mr. Oscar Haise, at Birmingham, Ohio, in 1905. The crop in the Hudson orchard was short, while that in the other orchard was good, but nearly twice the number of trees were used in the former orchard.

In Table I no sound fruit was recorded when the count of the windfalls was made in August. So few sound apples were found that no record was made, but in later experiments the numbers were carefully noted, as is shown in Table II.

TABLE I.—*Comparison of sound and wormy fruit from sprayed and unsprayed trees in Mr. R. L. Hudson's orchard, 1903.*

Number of trees.	First spraying.	Second spraying.	Third spraying.	Windfalls.		Picked fruit.		All apples.		Picked apples.		Difference in percentage of improvement between computations made from all apples and those made only from picked apples.
				Aug. 4; wormy.	Sept. 23; wormy.	Wormy.	Sound.	Per cent sound.	Percentage of improvement from spraying.	Per cent sound.	Percentage of improvement from spraying.	
10	....	....	....	2,428	1,359	1,172	376	7	....	24	....	....
10	Disparene	....	Disparene	156	187	229	1,934	77	70	90	66	4
10	Disparene and Bordeaux mixture.	Disparene and Bordeaux mixture.	Disparene	468	554	864	4,417	70	63	84	60	3

TABLE II.—*Comparison of sound and wormy fruit from sprayed and unsprayed trees in Mr. Oscar Haise's orchard, 1905.*

Number of trees.	First spraying.	Second spraying.	Third spraying.	Windfalls.				Picked fruit.		All apples.		Picked apples.		Difference in percentage of improvement between computations made from all apples and those made only from picked apples.
				Aug. 1.		Oct. 13–21.								
				Wormy.	Sound.	Wormy.	Sound.	Wormy.	Sound.	Per cent sound.	Percentage of improvement from spraying.	Per cent sound.	Percentage of improvement from spraying.	
5	....	....	....	995	357	558	39	1,342	247	18	....	16	....	....
6	Disparene	....	Disparene	137	884	45	516	103	4,488	96	78	98	82	4
6	Disparene and Bordeaux mixture.	Disparene and Bordeaux mixture.	Disparene	82	916	68	676	169	4,086	94	76	96	80	4

It will be noted in Table I that on the check rows, where all the apples were computed, only 7 per cent were sound, and when only the picked fruit was used the sound apples amounted to 24 per cent. This was due to the large amount of wormy fruit found on August 4 and September 23. The percentage of improvement is secured by subtracting the percentage of sound fruit on the check row, made by each method of computation, from that secured on the treated rows. This gives a balance of 3 and 4 per cent as a result of the different methods of computation, the larger percentage in the results being in favor of considering the entire crop.

In Table II, if the same methods are followed, a 4 per cent difference is shown, but this increase is in favor of the method where only the picked fruit is used. If it is assumed that the correct method is to have all of the fruit grown on the tree considered in deciding the percentage value of treatment, then the other method shows 4 per cent decrease in sound fruit in Table I and 4 per cent increase in Table II. It is therefore evident, as shown by these tests, that the error made by using only the picked fruit may range from none to 8 per cent in any experiment.

THE CONTROL OF THE CODLING MOTH IN THE ARID REGIONS.

By E. D. BALL, *Logan, Utah.*

The codling moth (*Carpocapsa pomonella* L.) is by far the most serious pest with which the apple grower in the arid regions has to contend. The unsprayed orchards will average, taking one year with another, fully one worm for each apple. In a year of abundant crops there will be some apples remaining sound, but the inevitable light crop following this is likely to have three or four worms to an apple.

That thorough and persistent spraying will control the codling moth has been demonstrated so many times as to appear at first sight almost axiomatic, yet when the writer took up the work in Utah, in the fall of 1902, he found a very deplorable state of affairs existing throughout the State. The codling moth had evidently been increasing in number and destructiveness for a series of years, and many of the leading fruit growers, who had formerly handled it with ease, were now meeting with very indifferent success or failing entirely to control it. Numerous instances were cited where from 4 to 6 or even more sprayings had failed to save the crop, while those who succeeded in getting 75 to 85 per cent of the picked fruit sound were considered highly successful. To add to the confusion, the cry had gone forth that the poisons were adulterated, that early sprays were of little value, and that three or even four or more broods were to be expected in a season, so even those who were disposed to profit by their failures knew not which way to turn. Further investigation revealed the fact that a somewhat similar condition prevailed throughout the entire intermountain region.

In view of this condition of excessiveworminess in apples and the general uncertainty that prevailed with reference to so many of the factors involved, it was decided to take up but one factor at a time and try to work that out by exact methods, so that whatever was discovered would be the result of known factors and could be explained by the known variation in the factors according to the needs of the experiment. In this way it has been possible to get quite definite results on several factors in the course of the four years' work, and the most important ones of these are summarized below.

The poisons were first investigated and were found to be first class in every respect. A few samples of Paris green had been found in the West that contained some free arsenic, but that would rather increase than decrease their killing power, so the failure of the spraying could not be laid at that door.

NUMBER OF BROODS.

In the work on this insect in Colorado, during the time the writer was an assistant at the State agricultural experiment station, the fact that there were two definite generations in that region and that these generations occurred at fairly definite times was thoroughly established. These tests were carefully repeated for northern Utah conditions, and a life-history chart showing the times of appearance of all stages of the two generations was published in Bulletin 87 of the Utah Agricultural Experiment Station.

From these investigations it was found that there would be a period of a few days in which it would be possible to separate the few worms of the two broods then occurring in the apples. This period, as was shown by reference to the chart above mentioned, occurred during the first few days in August in a normal season. As on the accurate separation of the damage done by each brood depended much of the value of the other data obtained, this damage was carefully checked up each year, and in no case was there more than 1 per cent of the "total wormy" in doubt, and often almost no doubtful cases appeared.

In practical work methods must come before results; but in this summary it has been thought best to give results first, and then the full significance of the methods that gave them can be more fully appreciated.

RELATIVE VALUE OF THE EARLY SPRAYINGS.

(Fig. 1.)

Careful tests of the relative value of each of three early sprayings were first made in 1905. The first spraying was applied just after the blossoms fell, the second ten days later, and the third fifteen days after that. Each spraying was tested alone and again in combination with the others and the results compared. The tests were carried on in five complete series, three on different blocks of Ben Davis and one each on Esopus and Missouri Pippin. All five tests gave similar results, and they are summarized in the following table:

TABLE III.—*Worms killed in the first brood by early sprayings.*

First spraying.	Second spraying.	Third spraying.	Total number of wormy apples.	Number of worms killed.	Percentage killed.	Number of apples with calyx wormy.	Percentage killed.	Number of apples with side wormy.	Percentage killed.
....	....	....	72	0	0	31	0	41	0
....	....	1	....	0	0	....	0	....	0
....	1	....	15	57	79	5	84	10	76
1	....	....	8	64	89	1	96	7	83
1	1	....	4	68	94	$\frac{3}{5}$	98	3	93
1	1	1	3	69	96	$\frac{2}{5}$	99	2	95

In the plat where the third spraying alone was given a few more wormy apples are shown than in the unsprayed block. This of course meant that the third spraying alone was of little value and that the trees happened to average a few more worms than the unsprayed. They were therefore treated as an unsprayed lot and averaged in with this lot to get the 72 wormy. This spray, when applied with the others, killed one more worm; and, strange as it may seem, every set showed this same result, so it should be given full credit for that worm.

The second spray, when applied alone, killed almost four-fifths of the worms, and when applied after the first spraying killed half of what would have been left. The first spray proved to be the best, killing almost nine-tenths of the worms when applied alone and when applied with the second killed 94 per cent.

The difference between the two sprayings was shown in every set but one, and there they were equal, while the increased value by applying both together was shown in every case.

WHERE THE WORMS WERE KILLED.

Examining these results to see where the worms were killed, we found that of the 15 worms left by the second spraying only 5 went into the calyx; of the 8 left after the first spraying, only 1 went in at that point; and when these two sprayings were combined an average of less than 1 calyx worm to a tree was obtained. In general, this shows that such spraying practically exterminates the worms that go in at the calyx and also shows the superior value of the first spraying in bringing this about.

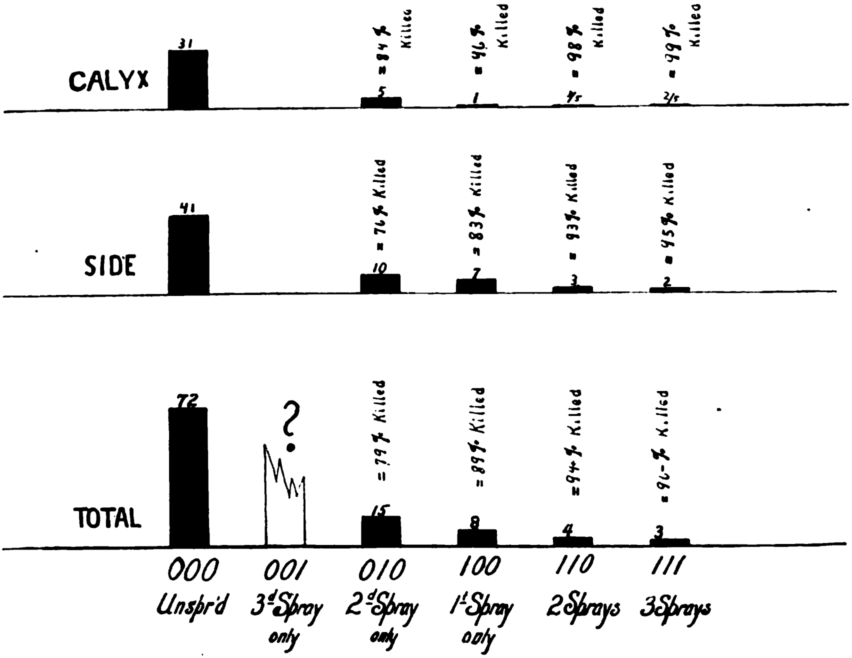

FIG. 1.—Chart to illustrate relative value of early sprayings on the first brood of "worms" of the codling moth.

Of those going in on the side a slightly larger percentage escaped, and as would be expected there was also less difference in killing power of the two sprayings, and more gained by combining them. Though lower than in the calyx, the killing power here indicated is very high.

RESULTS OF SPRAYINGS IN THE SECOND BROOD.

(Fig. 2.)

TABLE IV.—*Worms killed in the second brood by early sprayings.*

First spraying.	Second spraying.	Third spraying.	Total number of wormy apples.	Number of worms killed.	Percentage killed.	Number of apples with calyx wormy.	Percentage killed.	Number of apples with side wormy.	Percentage killed.
....	....	....	216	0	0	101	0	115	0
....	....	1	....	0	0	....	0	....	0
....	1	....	120	96	44	41	59	79	31
1	....	....	78	138	64	8	92	70	39
1	1	....	48	168	78	3	97	45	61
1	1	1	48	168	78	4	96	41	62

The results of spraying in the second brood are an almost exact duplication of those in the first, with the number of worms to be killed trebled and the killing power somewhat reduced, the reduction, however, being almost entirely in the killing of the worms infesting the fruit at the side.

It is hard to believe that two sprayings applied before June 10 could kill over three-fourths of the worms appearing in August and September, but the results are so uniform throughout each set that there can be no question about their general accuracy.

These results were obtained on trees averaging about 3,500 apples apiece; so the 4 worms escaping in the first brood together with the 48 in the second would make a total of almost exactly 1½ per cent of wormy fruit for the year remaining after two sprayings.

VALUE OF TWO EARLY SPRAYINGS.

The question of the value of two early sprayings was taken up first in 1904 and the results published in Bulletin 95 of the Utah Station. The comparative value of the two early sprayings in 1905 has been shown in the previous table. Some of the plats, however, did not contain trees enough for a complete test and so were not included in the first set.

Omitting in the second-brood tables the sets in which the results were obscured by lack of apples for the worms, in the first year we get the following summary for all plats:

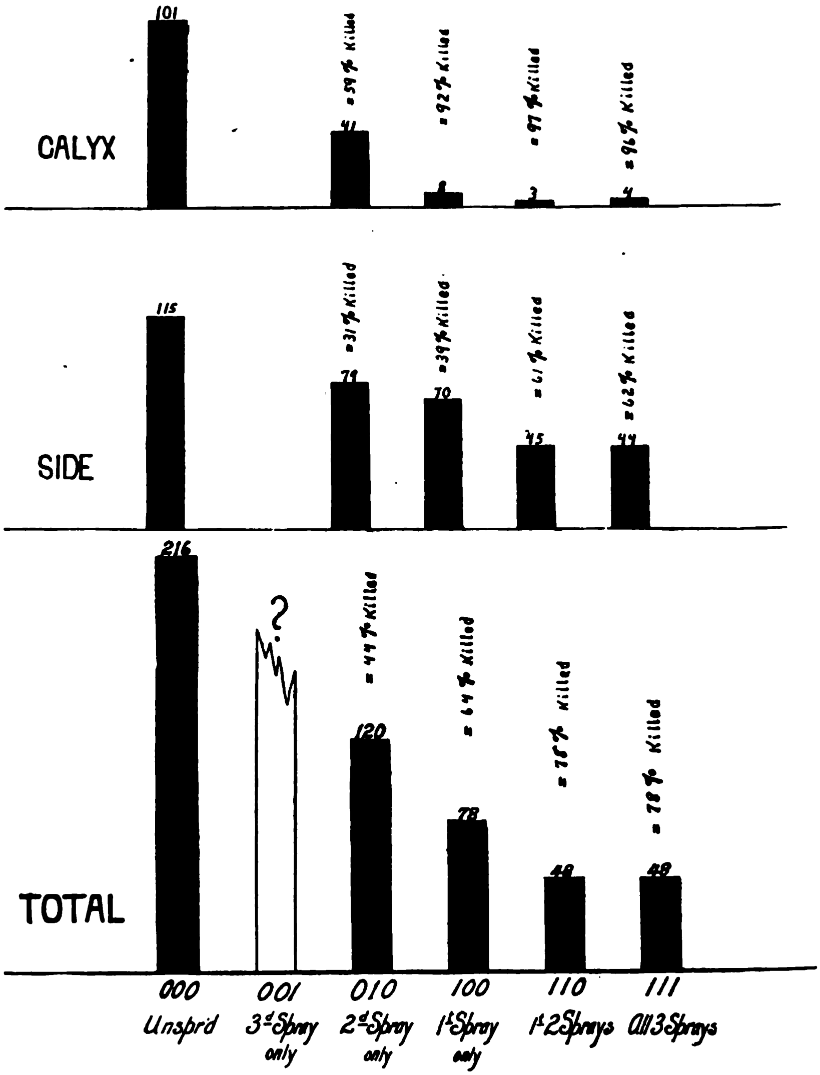

FIG. 2.—Chart to illustrate relative value of early sprayings on the second brood of "worms" of the codling moth.

TABLE V.—*Worms killed in first brood by two early sprayings, Smart & Hatch orchard.*

First spraying.	Second spraying.	1904.	1905.	1905.	
		Total wormy apples.	Total wormy apples.	Number of apples with calyx wormy.	Number of apples with side wormy.
....	....	247	97	65	32
1	1	27	6	1	5
Worms killed....		220	91	64	27
Per cent killed ..		89	92	98	84

TABLE VI.—*Worms killed in second brood by two early sprayings, Smart & Hatch orchard.*

First spraying.	Second spraying.	1904.	1905.	1905.	
		Total wormy apples.	Total wormy apples.	Number of apples with calyx wormy.	Number of apples with side wormy.
....	....	712	273	177	96
1	1	236	64	6	58
Worms killed....		476	209	171	48
Per cent killed ..		67	76	97	40

Tables V and VI show clearly the reduction in the number of worms the second year of spraying and also show a corresponding increase in the killing power of the early sprays. This increase is probably not real; instead it can be taken to mean that in the first test some apples on the unsprayed trees harbored more than one worm. All of the records indicate that the more worms there are, up to nearly 1 to each apple, the larger the percentage that will be killed.

VALUE OF THREE LATE SPRAYINGS.

Three late sprayings were applied to the second brood of worms in 1904 and again in 1905. They were applied with the same nozzle used in the early sprayings, but the nozzle was held farther away and spraying stopped as soon as the trees began to drip. The first of the late sprayings was applied as soon as the second-brood worms began to enter and the other two at 15-day intervals.

Three separate tests were made in 1904. The first was on 12 trees in an orchard that had no early spraying. The trees were about one-third wormy in the first brood, an indication that the apples would be entirely destroyed unless sprayed. Results, counting only second-brood injury, were as follows:

TABLE VII.—*Results of three late sprayings alone, in Hoggan orchard, 1904.*

	Wormy apples.	Sound apples.
6 unsprayed trees averaged..........	267	0
6 late sprayed trees averaged..........	254	8

There were no sound apples on either set at picking time. The 8 sound apples on the sprayed trees were windfalls. In fact there were very few apples left at picking time. The only difference that could be noted was that the apples from the unsprayed trees had 1 calyx worm each and 3 or 4 on the sides, while the sprayed ones were also all calyx wormy, but had an average of only about 1 on the side.

The second test was on unsprayed checks in the twice-sprayed Smart & Hatch orchards. These trees were nearly one-third wormy in the first brood, but about two-thirds of these worms were caught under bands, and the resulting moths from the remaining worms would, of course, spread out over the sprayed trees, so that there would be many less worms in the second brood than if the orchard had been unsprayed. On two varieties many of the apples on the unsprayed checks had more than one worm, and the results in sound apples are again too low to show the real killing power of this late spray. They gave averages as follows:

TABLE VIII.—*Results of three late sprayings alone in badly infested blocks in Smart & Hatch orchards, 1904.*

	Wormy apples.	Sound apples.
Unsprayed checks	562	252
Late sprayed checks	375	519

Many of the sound apples on the unsprayed trees were windfalls and most of the rest were below and inside. The outer and upper apples were badly infested.

On the third variety there were apples enough for the worms and to spare, and these results should show the full killing power of the sprayings when applied alone.

TABLE IX.—*Results of three late sprayings alone in moderately infested blocks in Smart & Hatch orchard, 1904.*

	Total number of wormy apples.	Number of apples with calyx wormy.	Number of apples with side wormy.	Percentage of sound apples.
Unsprayed checks	712	487	225	51
Late sprayed checks	193	120	73	76
Worms killed	519	367	152	....
Percentage killed	73	75	68	....

That the sound apples in Tables VIII and IX must be credited to the fact that the early two sprayings reduced the number of worms in the orchard, is evident on comparison with the first table, where there were no early sprayings. There was nearly the same number of worms in the first brood in each orchard, and without spraying the results would, no doubt, have been nearly the same.

That the late sprayings alone are not to be considered as a means of controling the codling moth under badly infested conditions is abundantly shown by the above results. Therefore their true value to us is their killing power when applied in connection with the early sprayings, as shown below.

In the third test the three late sprayings were applied to trees that had received the two early sprayings. Three varieties were used and gave similar results, which are averaged in Table X.

TABLE X.—*Results of three late sprayings on trees that had received two early ones, Smart & Hatch orchard, 1904.*

	Total number of wormy apples.	Number of apples with calyx wormy.	Number of apples with side wormy.
Two early sprayings	417	106	311
Two early and three late sprayings	112	35	77
Worms killed	305	71	234
Percentage killed	71	67	75

The number of worms to be killed is much smaller than before, and the proportion of "calyx wormy" to "side wormy" is reversed as a result of the high killing power of the early spraying on the calyx worms. The killing power of the late sprayings, however, was only reduced 2 per cent below that shown when they were applied alone.

This experiment was repeated in 1905 with a still smaller number of worms left after the two early sprayings. A still further decrease in killing power of only 1 per cent is shown below:

TABLE XI.—*Result of three late sprayings following two early ones, Smart & Hatch orchard, 1905.*

	Total number of wormy apples, second brood.	Number of apples with calyx wormy, second brood.	Number of apples with side wormy, second brood.
Two early sprayings	64	6	58
Two early and three late sprayings	19	3	16
Worms killed	45	3	42
Percentage killed	70	50	72

In this case the number of "calyx wormy" was so small that the results would have had to be expressed in fractions to have been accurate. There were six sets in the experiment, and it is worthy of note that on the two wormiest ones the highest killing power was shown.

Examining to see where the worms were killed we found that there was little difference in the percentage killed in the calyx and side. Wherever the largest number of worms were, there the percentage killed was the highest.

THE RELATIVE VALUE OF EARLY AND LATE SPRAYINGS.

(Fig. 3.)

The entire value of the late sprayings can be measured by the number of worms killed in the second brood, and is easily obtained from the above tables. In the case of the early sprayings the problem is much more complex. A certain number are killed in the first brood, still more in the second, but by killing the worms in the first brood a larger number are prevented from appearing in the second. This latter factor is no doubt variable, and up to the present time no method has been devised by which the ratio of increase can be accurately determined. Estimating this increase at five times is doubtless

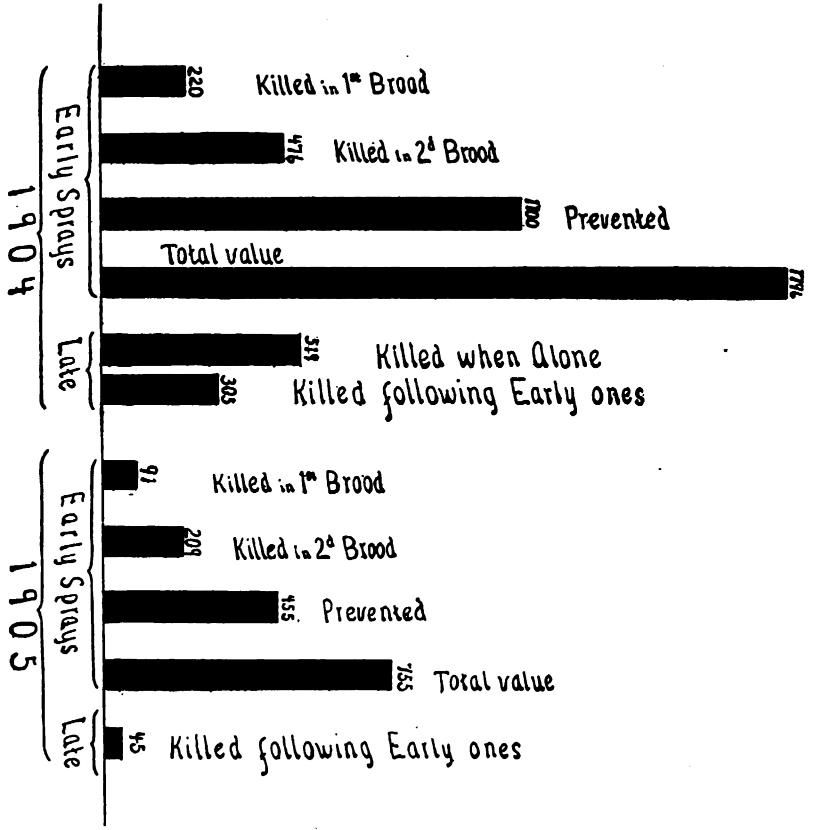

FIG. 3.—Chart to illustrate relative value of early and late sprayings for the codling moth.

conservative, as all other authors have placed it higher; and by using that number in connection with the results found before we get the following summary:

TABLE XII.—*Relative value of early and late sprayings in 1904.*

Value of early sprayings:	
Worms killed in first brood	220
Worms killed in second brood	476
Worms killed in first brood would have increased to	1,100
Total value of early sprayings	1,796
Value of late sprayings:	
Worms killed when applied alone	579
Worms killed when following early ones	305
Total value of late sprayings either 579 or 305.	

This comparison shows that the early sprayings have a protecting power over three times as great as that of the late ones when applied alone and under the most favorable conditions, and almost six times as great as the late sprayings when following the early ones. Still it does not bring out the full value of the early sprayings in comparison with the late ones, as the results in the following year will show.

TABLE XIII.—*Relative value of early and late sprayings in 1905.*

Value of early sprayings:	
Worms killed in first brood	91
Worms killed in second brood	209
Worms prevented in second brood	455
Total value of early sprayings	755
Value of late sprayings:	
Worms killed when following early ones	45
Total value of late sprayings	45

Here we see that the effect of the early sprayings in 1904 was cumulative and resulted in a marked decrease in the number of worms appearing the following year. As a result, the early sprayings destroyed so large a percentage of the worms that there was a striking decrease in the number of worms killed by the late sprayings and a corresponding decrease in the comparative value of the late sprayings as compared with the early ones.

Comparing the results of two years we find that the late sprayings which followed the early ones killed one worm to the early ones' six the first year and only one to the early ones' 16 the second year. By the third year the worms were so reduced in numbers that no late sprayings were applied.

RESULTS IN OTHER YEARS.

No other tests of the late sprayings than these enumerated have been made. In the other tests the number of worms left after the early sprayings has not been sufficient to give accurate results, and none has been applied.

The first test of the relative value of the early sprayings was made on a single variety in 1904. The results in the first brood were good, but in the second brood most of the apples on the unsprayed trees and some of those on the once-sprayed trees fed more than one worm, so that the number of apples saved did not show the real killing power of the sprayings.

TABLE XIV.—*Worms killed in the first brood by early sprayings, Smart & Hatch orchard, 1904.*

First spraying.	Second spraying.	Total number of wormy apples.	Percentage killed.	Number of apples with calyx wormy.	Percentage killed.	Number of apples with side wormy.	Percentage killed.
0	0	439	0	289	0	150	0
1	0	192	66	110	62	82	45
1	1	37	92	10	97	27	82

This same orchard was used for the elaborate test of 1905, the result of which has been given. In 1906, although only about one tree in seven was bearing at all and those only about half a crop, three varieties were used in a third test. On account of the small number of trees bearing, no unsprayed checks were left and results can only be compared with those of former years.

Two other tests were made this year (1906) to see if the same results could be obtained in the earlier and warmer sections of the State. One test was made on three blocks of Ben Davis at Lehi, and the other one on two blocks of the same variety at Provo.

In the case of the Lehi orchard the trees were young and bearing only from 300 to 350 apples apiece. The unsprayed trees were nearly one-third wormy in the first brood, showing that the orchard would have been entirely wormy if unsprayed; consequently there were worms enough in both broods to give fairly accurate results. These results are averaged in Tables XV and XVI.

TABLE XV.—*Worms killed in the first brood by early sprayings. Lehi orchard, 1906.*

First spraying.	Second spraying.	Total number of wormy apples.	Percentage killed.	Number of apples with calyx wormy.	Percentage killed.	Number of apples with side wormy.	Percentage killed.
0	0	45	0	17	0	28	0
0	1	11	76	1	94	10	64
1	0	+ 4	90	+ 0	99	+ 4	84
1	1	8	82	+ 0	99	8	72

TABLE XVI.—*Worms killed in the second brood by early sprayings, Lehi orchard, 1906.*

First spraying.	Second spraying.	Total number of wormy apples.	Percentage killed.	Number of apples with calyx wormy.	Percentage killed.	Number of apples with side wormy.	Percentage killed.
0	0	75	0	28	0	47	0
0	1	31	59	2	93	29	38
1	0	21	72	1	97	20	57
1	1	20	73	+ 0	99	20	57

These results show an even higher killing power in the calyx than in the former tests, due, no doubt, to the fact that the small trees were easier to spray thoroughly and that more liquid was applied in proportion to the apples.

In the Smart & Hatch orchard in 1906 and in the Provo tests the number of worms present to begin with was much smaller, and those left after the early sprayings were so few in numbers that in some cases the individual variation in the trees was greater than the difference between the sprayings. The actual percentages are therefore of little value. This is readily understood if one considers that with so few moths in the orchards some trees might not be visited at all.

TABLE XVII.—*Worms killed by early sprayings in Smart & Hatch orchard, 1906.*

		First brood.			Second brood.		
First spraying.	Second spraying.	Total number of wormy apples.	Number of apples with calyx wormy.	Number of apples with side wormy.	Total number of wormy apples.	Number of apples with calyx wormy.	Number of apples with side wormy.
0	0	(?)	(?)	(?)	(?)	(?)	(?)
0	1	7	2	5	31	0	31
1	0	23	6	17	74	25	49
1	1	5	1	4	42	6	36

TABLE XVIII.—*Worms killed by early sprayings in Provo orchard, 1906.*

		First brood.			Second brood.		
First spraying.	Second spraying.	Total number of wormy apples.	Number of apples with calyx wormy.	Number of apples with side wormy.	Total number of wormy apples.	Number of apples with calyx wormy.	Number of apples with side wormy.
0	0	17	9	8	21	5	16
0	1	8	2	6	8	1	7
1	0	5	1	4	8	1	7
1	1	4	0	4	11	1	10

The general average of Tables XVII and XVIII, with one exception, will be seen to be the same as that of the others. The actual percentage killed is less than where there were more worms; but as the Smart & Hatch orchards were only 3 per cent wormy for the season and the Provo orchard but a trifle over 1 per cent wormy, the results are entirely satisfactory.

The one exception to the general average is the relative value of the first and second sprayings as shown in the Smart orchard. In all other tests the first spraying has proved to be the best, and in all these cases the two sprayings have been applied alike. In this one case the writer, who has done most of the spraying himself, was away superintending the work in other parts of the State leaving the work on this orchard in charge of an assistant. On returning, the amount of poison found in the calyx cups was so small that an investigation was made, and it was found that the assistant had turned the work over to inexperienced students to carry out, with the inevitable results. In order to make the two sprayings "average up" with those of other years the second spray was applied with extra care and in larger amounts than usual, hence the reversal of the ordinary results.

AMOUNT OF SPRAY TO APPLY.

The above results, although not intended as an experiment, show that the relative value of a spray can be easily altered by a change in the method of applying it or in the amount applied.

In order to test the question as to whether it was possible to spray too much, two trees were sprayed in the ordinary way and two were soaked until the water stood on the ground in puddles, at least four times the ordinary amount of spray being applied, with the following results:

	Wormy apples, first brood.	Wormy apples, second brood.
Ordinary sprayed trees averaged	9	147
Soaked trees averaged	8	96

This shows that there is no danger of overspraying in the early sprays and indicates that even our liberal application might be increased with profit.

COMMERCIAL RESULTS.

All tests have been carried on in orchards of from 2 to 5 acres, and the results given for the twice-sprayed trees have represented the condition of the orchards as a whole. Besides this, more and more of the fruit raisers have adopted this method each year, until in 1906 the majority of the orchards of the State, as well as a large number in Idaho and Oregon, were sprayed by this method with the most satisfactory results ever obtained. In September the writer visited commercial orchards in which a calyx-wormy apple was such a rare thing that it was only after careful and prolonged search that one could be found.

METHODS USED.

In each experiment the trees selected for the different tests have been of the same variety, the same size, and bearing as nearly the same number of apples as possible. In every test the orchard has been sprayed twice and the spraying done before the trees were selected, except for those trees on which the given spraying was omitted, so that the spraying represents the average condition of a commercial orchard. Check trees have been scattered through the blocks so that one check would not influence another. All important tests have been made in parallel series on at least three winter varieties, and all have been or will be repeated through a series of years, and in the warm and cold sections of the State. Unsprayed trees have been left very sparingly, as one badly infested tree will noticeably influence half an acre. The check trees have been banded, the bands examined every three days, and the worms placed in cages and bred for the life history work. The remaining trees of the orchard have not been banded, and the worms caught on the check trees do not more than offset the larger number escaping from the unsprayed checks, thus leaving the orchard in about the same condition as if there were no check trees present.

All apples that set on the check trees were accounted for. Windfalls were picked up every three days and sorted into "sound," "calyx wormy" and "side wormy." All that were the least questionable were sliced open to determine whether the calyx had been entered. At the proper time to divide broods all the apples on the trees were examined and all wormy ones of the first brood recorded. These, with the windfalls to date, made up the damage from the first brood of worms.

Complete records were kept on 28 trees in 1904, 64 trees in 1905, and 50 trees in 1906. The 64 trees used in the comparison of early sprayings in 1905 carried 220,000 apples, nearly all of which were handled three times during the investigation.

COMPARISON OF RESULTS.

In all the experiments the results have been given in the actual number of wormy apples found in each brood under each different test, and the percentage given shows the actual killing power of the spray for that brood. In one case, for example, the unsprayed trees averaged in the first brood 72 wormy apples, while the twice-sprayed ones averaged only 4 wormy, showing that 68 worms, or 94 per cent of those that appeared, were killed. There can be no question of the accuracy of this method for the first brood, because in this brood the moths will be evenly distributed throughout the block without reference to sprayed or unsprayed trees. In the second brood the problem of getting a fair standard of comparison was a little more difficult; but by banding the unsprayed trees and catching two-thirds or over of the first-brood worms it was thought that the few remaining worms in excess of the number on a sprayed tree would be so evenly scattered among the surrounding trees, especially where the unsprayed trees were well distributed through the block, that they would fairly represent the average distribution of the worms in the orchard. The results in the second brood have in every case agreed so remarkably with those in the first that there seems to be no question but that this method was fairly accurate.

All the tests have shown that the variation in the number of worms attacking trees of equal size is very slight, as compared with the variation in the number of apples that they may bear; therefore the method of comparing the actual number of wormy apples is much more accurate than the method of comparing percentage of sound and wormy fruit.

In these tests none of the wormy apples from the first brood has been found on the trees at picking time, and the percentage of those of the second brood remaining has varied so greatly, under different conditions and on different varieties, that results, based on percentage of wormy fruit at picking time, appear to be of doubtful value at best, and where they have included different varieties in the same test, of no value at all.

WHAT CONSTITUTES THOROUGH EARLY SPRAYING.

If the first spray is applied for the purpose of placing poison in the calyx cups—and all will agree to this, I think—then the test of the efficiency of such a spray will be the amount of poison found in the cup after it has closed. Now, paradoxical as it may sound, it is not as easy to spray into an open calyx as it is into one that has nearly closed. This will be made clear by referring to figure 4, subfigure 1, where a cross section of an open cup is shown with the pistil in the center and the circle of stamens forming a tight roof above, as seen at 1*a*. A week or ten days later the calyx lobes have nearly closed above, the opening being filled with the stamens and pistils, as seen in subfigure 2. By this time the stamen "bars," as I have called them, have shrunken and become more or less twisted, so that there are many open spaces between them, as seen in 2*a*. Later the calyx lobes close tightly and the "bars" shrivel still more, as seen in subfigures 3 and 3*a*.

By reference to subfigures 2 and 3, it will be seen that there are two distinct cavities at first, one above and one below the stamens, either of which might be called the calyx cup, and which have been treated as a single cavity by most writers.

A large number of spraying tests have been made, and by using Paris green without lime the location of each grain of poison could be readily made out with a strong hand lens.

A fine mist spray applied only to the point of dripping was first tried. This left grains of poison well distributed over the inside of the calyx lobes and on the upper surface of the stamens when applied to the open calyx, as shown in subfigure 1. When this spray was continued until the drops ran together, the greater amount of the poison was deposited in a ring around the base of the stamens. When applied to the closing calyx of subfigure 2, it simply deposited a few grains in the outer part of the throat and on the tops of the stamens and pistils. In the hundreds of cases examined there were but few in which there was any poison to be seen in the lower cup and then only in small amounts. The fine, mist-like drops did not seem to be able to force their way through the fleshy stamens in the open calyx nor through the hairy mass in the throat of the closing calyx. Simpson states that in his experiments he "was unable at any time to distinguish any particle of spray inside the tube," and he lays especial stress on the fine, mist-like spray. Slingerland states that the spray

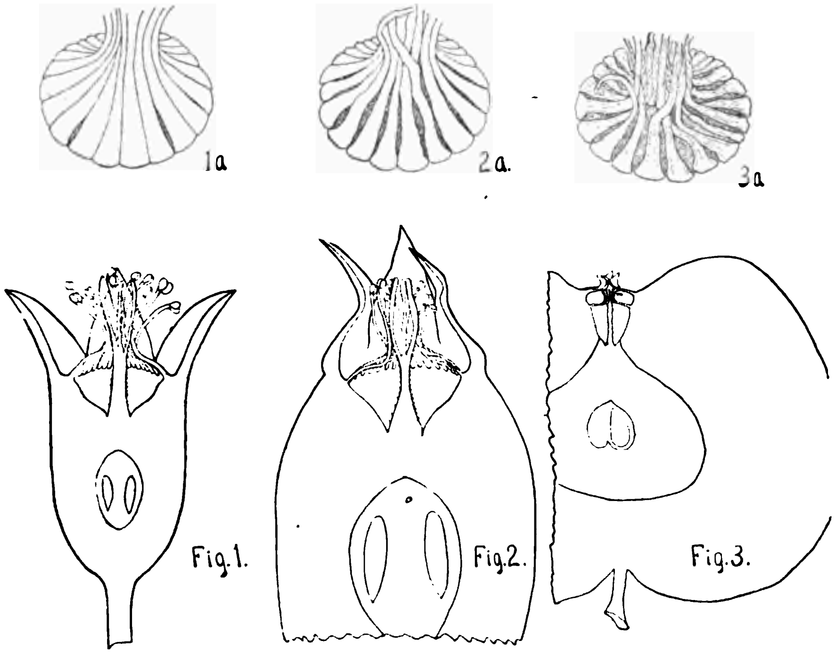

FIG. 4.—The condition of the calyx cup of the apple in relation to spraying for the codling moth: *Fig. 1*—A calyx cup, five days after the petals fell, split open to show two cavities; *1a*, the roof of stamens as seen from above. *Fig. 2*—A calyx cup two weeks after blossoming, showing the calyx lobes above; *2a*, the stamens from above, to show spaces. *Fig. 3*—The relation of the two cavities in a nearly grown apple; *3a*, stamens from above.

lodges in the saucer-like calyx, but does not distinguish between the two cavities. He was able to find it two weeks later by chemical analysis.

A spray thrown up into the air and allowed to fall in large drops deposited poison much like the oversprayed mist, but with much less regularity.

A driving spray of fine drops thrown with sufficient force to go 6 or 8 feet before breaking into a mist was next tested. This was applied with the nozzle held so that it would throw the spray straight into each cup from a distance of from 1 to 3 feet, and was continued until each fruit cluster was freely dripping. When applied to the open calyx this spray left a rim of poison around the base of the stamens, scattered masses of it here and there in the central mass of stamens and pistils, and forced some down through the roof of stamens into the cup below; part of this, no doubt, passed through the minute openings and part was probably forced down through the center.

When applied to a partly closed calyx, the finer drops were driven straight down through the shrunken stamens' "bars" and gathered in the lower cups where the poison was deposited. Series of countings gave an average of about 10 grains of poison visible in the lower cups following this spray.

As will be explained later, this method of spraying was found to place the poison where the most worms entered, and was adopted for all early sprays, with 15 grains of poison in the lower cup as a standard for two thorough sprayings. Card notes that coarse spraying placed more poison in the calyx cups, but evidently referred to the outer one, as he continues that it was easier to fill them when wide open, though more remained when partly closed.

METHOD OF APPLYING A DRIVING SPRAY.

In order to apply such a spray in a uniform and thorough manner, it was found necessary for the operator to be on a level with the upper limbs of the trees. From such a position, by using a 10-foot extension pole with the nozzle set at an angle of 30° to the pole, one could spray from above down and from the sides in; and by spraying from all four quarters of the tree one could force the poison straight into each blossom at close range. Spraying was directed entirely at the blossoms, no attention being paid to anything else, and no spraying done where there were no blossoms. Each cluster of blossoms was gone over two or three times and left freely dripping. In practice it was found that this required about 1 gallon of liquid at each spraying for every 3 bushels of fruit expected, and cost three-fourths of a cent a bushel.

The spray was thrown through a Bordeaux nozzle set at almost its widest limit on the broadest side, and under a pressure of from 85 to 120 pounds. Paris green was used, without lime, at the rate of 1 pound to 120 gallons of water in all tests. (This could only be done in an arid climate.) Duplicate series were carried through with 6 pounds of lead arsenate to 120 gallons of water in three cases without showing any difference in results.

Heavy rains followed the sprayings in several cases, without lowering their killing value enough to be noticeable. This was no doubt due to the fact that the effective poison was placed in protected places.

HOW THE EARLY WORMS ARE KILLED.

In these experiments very few worms of the first brood have been observed to go in on the free surfaces of the apples, and those mostly the later ones. Over two-thirds of this brood, on an average, went in at the calyx and most of the rest were found under leaves where apples touched, or were going in at some scar. Of those going in at the latter situations, no definite observations have been made as to how they are killed. That three-fourths or more of them are killed by the two sprayings has been repeatedly demonstrated. Examinations have shown that where two apples touch, a driving spray will often leave a film of poison around the spot, due no doubt to capillary attraction holding the liquid there until it dries. The same thing was true, but to a less extent, with touching leaves and scars. In fact, more poison was found in such situations from the driving spray than from a mist spray applied so as to give the maximum amount of surface coating. This may well account for a considerable number of those killed, but the entire subject is one for further investigation.

Of the fate of those going in at the calyx we are more fortunate in having definite information. In cutting the thousands of apples examined for poison a number of small worms were found in the lower cups; most of these were found crawling around, but in several instances dead ones were found where there was no sign of their having started to penetrate. More cases were found where a hole had been eaten a short distance into the pulp before the worm had died. In every instance where a dead worm was found poison was found in the lower cup.

Later an orchard was found that had borne a large and very wormy crop the previous year, and was now bearing a very light one. It had received one driving spray, and was being examined to find out whether late ones would be necessary just as the greatest number of the first brood worms were appearing. Some of the apples already showed castings in the blossom end; of the rest, an average of about 1 in 3 or 4 contained a live worm crawling around in the calyx, and almost all of these were in the lower cups. The spraying had not been well done, as less than half of the apples contained enough poison to be seen; but of those that did about one-third contained dead worms. Two "sick" worms and a number of fresh dead ones were found, but the great majority of the dead ones were only recognized by their shining black heads, and from that possibly a trace of a decayed body could be made out. In no case were two live worms found in the same cup, though in one case a live worm was found in both inner and outer cups. Live worms and dead ones were frequently found in the same cup; in many cases two, and in a few even more dead worms were found together. The climax was reached when three dead heads and a live worm were found in a single lower cup.

In only one case was a dead worm found above the stamens, and this one was on the shelf at their base. From the lack of dead worms above the stamens it was concluded that most of the live ones found on the outside were new arrivals, and had not yet made their way below. An examination of thousands of wormy apples with this point in mind showed that in 97 or 98 per cent of those classed as "calyx wormy" the entrance had been made from the lower part of the lower cup, from which it would seem that the method of spraying that would place the most poison in this region would be the best.

KILLING THE SECOND BROOD.

Many factors influence the number of worms entering the calyx in the second brood. Some always go in on the free surface of the apples, more go in where apples touch, but in our experiments, taking all the varieties through all the years, almost two-thirds of them have been found to go into the calyx. In slow-growing and stunted apples the calyx is often so tightly closed that it is hard for a worm to find an entrance, while in the fast-growing apples and the larger ones of all varieties the calyx often opens up again about the time the worms are appearing.

Only a little of the poison of the first sprayings can be found in even the most protected locations, and of course none would remain on the free surfaces of the apples even if it had been left there (and this sort of spraying leaves very little in the first place), so it was rather hard to explain how the worms were killed on the sides, yet every record has shown that some were killed. This is a subject that needs careful investigation.

In the case of the calyx worms, however, abundant evidence was at hand to show how they were killed. The poison placed in the calyx in June could be found in only slightly diminished quantities in August and September, and the record of 97 per cent of calyx worms killed was no more than was to be expected. Apples from trees twice sprayed in June, 1905, were exhibited in February and March, 1906, at the Northwestern Fruit Growers' Convention and the Idaho Horticultural Society, and in the majority of them poison could still be detected.

CONCLUSIONS.

(1) The poisons used in the intermountain region have been satisfactory.

(2) The codling moth is definitely two-brooded in this region.

(3) It is so abundant that from 5 to 8 ordinary sprayings have been necessary to control it.

(4) The driving sprays force the poison into the calyx cups and into the cracks and spaces between the apples where the first-brood worms enter.

(5) The first early spraying is the best, the second is nearly as good, and the third is of little value.

(6) Two early driving sprayings will kill an average of 90 per cent of the first brood of worms.

(7) By killing these worms in the first brood the greater part of the second brood is prevented from appearing.

(8) Sufficient poison is retained from the early sprayings to kill an average of 74 per cent of the second brood of worms.

(9) Two early sprayings correctly applied are worth from 6 to 16 times as much as three late ones.

(10) Over two-thirds of the first brood and nearly two-thirds of the second brood of worms enter the calyx.

(11) Of these worms entering the calyx, an average of 98 per cent of the first brood and 97 per cent of the second were killed by the two early sprayings.

(12) Of the worms entering the sides, an average of 78 per cent of the first brood and 52 per cent of the second were killed by the same sprayings.

(13) Each succeeding year of such spraying will reduce the number of worms remaining in the orchard.

Mr. J. B. Smith inquired if there was any special explanation why an early and a late spraying of Disparene showed a larger percentage of perfect fruit than when three sprayings were applied and Bordeaux mixture was added to the first two; also, whether Bordeaux mixture seemed to affect the efficiency of the poison.

In reply, Mr. Burgess stated that he could give no reason for the better showing made where only two sprayings were applied. In some cases Bordeaux mixture seemed to render the poison less effective, but in other experiments the opposite proved true. It did not seem advisable to leave out Bordeaux mixture, as in some regions its use was absolutely necessary for controlling apple scab and other fungous diseases.

Mr. Britton believed that in combining Bordeaux mixture with arsenate of lead the poison became less soluble, and this resulted in its killing fewer insects.

Mr. Sanderson, in speaking of the results secured by Mr. Ball, emphasized the desirability of having uniform methods of treatment, in order to secure experimental data which could be used for comparison.

Mr. Ball stated that in order to secure the results reported in his paper it was absolutely necessary to use a coarse driving spray, and that a mist spray, such as is usually recommended, would not drive the poison far enough into the calyx cups to be effective. He did not attempt to cover the fruit or foliage with the spray, but simply wished to fill the calyx with poison.

Mr. Fletcher pointed out the desirability of not casting any doubt on the efficiency of the methods now generally in vogue for controlling this insect. In Canada 70 per cent of the apple crop is saved by the present acknowledgedly imperfect spraying methods. He did not believe it necessary to lay so much stress on filling the calyx, and was decidedly in favor of delivering the spray in as mistlike condition as possible. With the pumps and nozzles in general use by farmers and fruit growers there was far too great a danger of going to the other extreme. Excellent paying results were now being secured by ordinary farmers with the mist spray which had been used for several years.

Mr. Quaintance pointed out that fruit-growing conditions in the Mississippi Valley and Eastern States were quite different from those in many sections of the West, as in Utah. The absence of rains there during the growing season largely obviated the necessity for the use of fungicides to control scab and other fungous diseases. While he did not doubt that it was entirely practicable to use a coarse spray for the codling moth in Utah and thoroughly drench the trees, this would be bad practice according to present ideas of spraying in the East, where a mist-like spray is desired to treat uniformly all parts of the foliage and fruit. Under present conditions of spraying, young apples are often russeted by the Bordeaux and arsenical treatment, especially by the one just after the petals have fallen, and a thorough drenching of the trees at this time, as advocated by Mr. Ball, would be likely to prove quite harmful in this way. He also called attention to excellent results which orchardists had been securing in the control of the codling moth in the East by the use of the mist spray, and that success depended more on spraying with good pressure and making the applications thorough than on anything else.

Mr. Ball remarked that this system of spraying had been tried in not less than forty orchards by commercial growers, and they were able to save at least 96 per cent of their crop; other growers who used the mist spray and made five applications rarely secured more than 90 per cent of sound fruit. It was absolutely necessary in Utah to produce perfect fruit, as this was the only kind that could be profitably marketed on account of the long distance which it must be shipped.

Mr. Saunders asked concerning the date of applying the second spraying, and Mr. Ball replied that this must be applied within ten days or, at the longest, two weeks after the first spraying, but the exact time depended on the condition of the calyx lobes. It must be put on before the lobes have closed.

Mr. Hopkins stated that his phenological investigations in West Virginia and other sections of the country showed conclusively that the dates of periodical phenomena of plants and insects must be determined for different localities, latitudes, and altitudes. For instance, the dates at which the apple leaf and flower buds open not only differ greatly in different localities and seasons, but in different varieties of apples in the same locality. The rate of difference from a given locality may not be far from four days for each 400 feet of altitude and four days for each degree of latitude—later at localities north or higher, and earlier at those south or lower.

The following paper was presented:

WHAT RESEARCH IN ECONOMIC ENTOMOLOGY IS LEGITIMATE UNDER THE ADAMS ACT?

By E. Dwight Sanderson, *Durham, N. H.*

The recent passage by Congress of "An act to provide for an increased annual appropriation for the agricultural experiment stations, and regulating the expenditure thereof," commonly termed the "Adams Act," in honor of its lamented author, the late Hon. H. C. Adams, of Wisconsin, should be made a notable milestone in the progress of economic entomology. This act provides that it shall "be applied only to paying the necessary expenses of conducting original researches or experiments bearing on the agricultural industry of the United States, having due regard to the varying conditions and needs of the respective States or Territories." The control of its proper expenditure has been placed in the hands of the Secretary of Agriculture, who has delegated his supervision to the Office of Experiment Stations of the Department of Agriculture. In endeavoring to secure the expenditure of the appropriation for original research within the intent of the law, the Director of the Office of Experiment Stations has consulted with the various station directors and workers, and at the recent meeting of the Association of Agricultural Colleges and Experiment Stations the discussion of this question was one of the leading features. The main question is, "What is 'original research * * * bearing directly on the agricultural industry?'" In general, the principles which should govern the problems for such research seem to have been satisfactorily defined for all parties concerned, but in outlining his own work under this act the writer has felt that some discussion as to just what lines of work are most needed or most desirable in economic entomology might not be amiss at the present time.

The term "economic entomology" seems to be one of those which has come into common usage but which has not been carefully defined. In a somewhat careful search of the dictionaries and the proceedings of this association no definition of the term has been found. Might we not describe it as the science of entomology as applied or related to human welfare? It is therefore narrower in its scope than the general ethology of insect life, though it usually includes the ethology of all forms of economic importance. For a general discussion of the objects and field of the economic entomologist I have seen nothing better than the remarks of Dr. S. A. Forbes, quoted by Dr. J. W. Folsom in his recent Entomology.[a] After reviewing with him the diverse sciences and arts with which the economic entomologist must deal, we might fairly question whether economic entomology is truly a science of itself or whether as economic entomologists, as we style ourselves, we are not really artisans applying the laws and knowledge gained from the true sciences. In any event, the science is a young one and a little definition of its objects and scope will not be out of place.

Economic entomology would therefore include the subjects of the relation of insects to human health, household insects, etc., while the Adams Act restricts us to work upon subjects related to agriculture. The economic study of mosquitoes is therefore not permissible under its terms. In general, our work will doubtless be restricted to work upon insects injurious to agriculture, for, although apiculture and sericulture are undoubtedly worthy objects for research by the economic entomologist, yet they have become so specialized that but few of us pretend having any practical knowledge of them such as would qualify for research.

Many of us have doubtless been surprised to find that, though constantly dealing with the term, our ideas of the true meaning of research are possibly somewhat indefinite. The dictionaries define research as "continued and diligent investigation; studious and laborious inquiry; systematic scientific investigation." (Standard Dictionary.) Hitherto a large part of our work as station entomologists has been in the nature of miscellaneous observations upon various insects demanding our attention, often involving considerable study; but how often has our work upon them reached the position where it might properly be called research in the true sense? It is obvious that for the best development of our science research is greatly needed at the present time, and we therefore welcome this increased appropriation with its restrictions to such use.

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[a] Entomology, with special reference to its biological and economic aspects. By Justus Watson Folsom. Philadelphia, 1906.

In considering the branches of economic entomology which will furnish a field for such "diligent investigation" we may study individual insects, groups of insects, or general principles governing insect life and control.

In the past our work has necessarily been largely a study of individuals, more especially as regards their life histories. In this work marked advance has been made in the past few years. We have come to see that if an insect is of sufficient economic importance to warrant investigation, the study must cover all phases of the insect's ethology and the testing of all possible means of control. For example, consider the work of Hunter and Hinds on the boll weevil, Quaintance's investigation of the bollworm, Doctor Forbes's studies of the corn root-aphis, Professor Crandall's work on the life history of the plum curculio, and some of the investigations of the codling moth. These studies must always remain classic in the annals of economic entomology from the fact that they have raised a new standard for work upon such insects of primary economic importance. The study of an individual insect, therefore, furnishes a worthy object for research, but the work must be exhaustive. A mere breeding of a dozen specimens in an insectary, testing a remedy which seems to be satisfactory, and the publishing of a bulletin outlining the supposed facts, is not research. It may be that such work is all that the economic importance of an insect pest warrants in many instances, but it is hardly research in the true sense. Whether the insect warrants true research work upon it will depend largely upon its economic importance. Thus the rusty tussock moth (*Notolophus antiqua* L.) is hardly of sufficient importance to warrant any lengthy study, while its brother, the white-marked tussock moth (*Hemerocampa leucostigma* S. & A.), might well receive the most careful research. In some instances, however, an insect may be peculiarly adapted to some research work in an effort to establish certain principles of insect life; but in such a case it is merely a means to an end and is not in itself the object of study. The larger part of our life-history studies and observations can therefore hardly come within the meaning of this act, though necessary and forming the foundation for the future development of the science.

In the study of groups of insects we deal with what is really a branch of systematic entomology, and which might properly be styled systematic economic entomology. Under this head comes the study of (1) taxonomic groups and (2) economic groups. If in his work the economic entomologist finds that he can not proceed further without a monographic revision of the family or genus with which he is most concerned, and if he is unable to secure the help of a satisfactory specialist for such work, why should he not himself undertake its revision, if he feels competent and able to do so? For instance, is not Doctor Hopkins's work on the Scolytidæ of fundamental economic importance? Would not careful systematic studies of the Aphididæ be of the greatest service to the economic entomologist, and can we ever be sure of just what we are dealing with in this most interesting and much neglected family until we do have such systematic work? Again, the economic entomologist constantly receives numerous caterpillars and larvæ of all orders, often of economic importance, which it is impossible for him to identify in the immature stages and which he must therefore rear before he can suggest remedial measures. These efforts at rearing are often unsuccessful, in which cases much time and labor is spent for naught. Systematic studies of insect larvæ, with monographic work enabling us to identify them, would be one of the greatest boons to the economic worker and save much really unnecessary work. Is not the systematic study of insect larvæ, therefore, a proper field for research by the economic entomologist, as related to agriculture?

Again, we may investigate economic groups as regards their economy, considering either taxonomic groups which are of general economic importance, such as the barkbeetles, or groups of insects affecting some one food plant, as corn insects, cotton insects, etc. When such studies cover the whole field in such a way that general methods of farm practice or procedure are worked out which will control all the common insect enemies of any important crop, are they not worthy objects of true research? Doctor Forbes's work on corn insects might furnish an example. It should be remembered, however, that mere general observations upon any class of insects and the compilation of a report upon them is not research; to come under that term the work must be clearly defined, systematic, and exhaustively studied. Probably much of such work upon groups of insects may well be deferred until more careful studies of many important individual pests have been made, though it will furnish an inviting field in the not far-distant future.

It is the study of the principles underlying insect life and control which, it seems to the writer, furnishes a field for research but little tilled and with much virgin soil. In his presidential address at the fifth meeting of this association, Doctor Forbes noted a satisfaction with the present methods and a dearth of new methods of work. Has not this tendency continued to some extent, and do we not need more pioneer work along the lines of pure science which will furnish a basis for the future development of economic entomology and insect control? Much has been done, which will be noted below; but there is certainly vastly more to do if our science is to make any marked advance in the future, comparable with the advances in other branches of science, or if advance in the control of agricultural pests is to equal that now occurring in the control of insects affecting health.

Such new principles may be sought and furnish objects for research in various phases of economic entomology.

(1) Our studies of life histories are principally of value in revealing the vital time at which an insect may be attacked, and often the method of control, but the time factor is the dominant one. Would not exhaustive studies of the relation of temperature, moisture, latitude, altitude, etc., in short, climatic influences upon the various stages and processes of the transformations of insects, be of the greatest value in revealing the time at which certain pests might best be fought in certain localities, and the number of generations and consequent destructiveness of a pest in different latitudes? Something along this line was done by Dr. A. D. Hopkins and Prof. F. M. Webster in their studies of the Hessian fly in West Virginia and Ohio, and recently by the staff of the Bureau of Entomology in their work upon the boll weevil and bollworm. The importance of such work seems to be increasingly appreciated.

(2) The structure and physiology of an insect, including its habits, determine to a large extent the method of control. We know that a chewing insect can usually be poisoned with arsenicals and that a sucking bug must be handled otherwise, but have we carried our studies of anatomy and physiology far enough? Might we not learn more of vital importance? In his presidential address at the eighth meeting, Prof. C. H. Fernald called attention to the need of our securing the cooperation of the chemist and physiologist, and the work of the gipsy-moth committee furnished some examples of the wisdom of this advice. Of even simple features of anatomy we are often ignorant. For example, the writer recently had difficulty in ascertaining whether the common imbricated snout-beetle (*Epicærus imbricatus* Say) was winged or not, and the matter was only decided by the kindness of Mr. Schwarz, who examined specimens in the National Museum, proving the species to be apterous. A very similar beetle affecting peach foliage in Texas was controlled by us by banding the

trunks of trees with insect lime and thus preventing its ascent. It is obvious that the imbricated snout-beetle can probably be handled in the same way; but this fact of its anatomy seems to have entirely escaped observation, nor was the writer able to find reference to the wings in any monograph. Again, experiments recently conducted at Cornell University have shown that a liquid lice killer applied to the perches will kill the lice upon fowls and is exceedingly efficient. How is this done? Possibly Professor Slingerland can inform us, but it is exceedingly suggestive in showing that some things are possible at which most of us would have scoffed had we not the evidence of competent observers. Might we not find that through study of the nervous system of insects and experiments with substances or means of affecting the nervous apparatus, a means of control for some pests might be found? Would not a study of the alimentary tract and its physiology be of value? These are but suggestions. Who can say what might come from such research?

(3) As regards the artificial control of insects with insecticides and apparatus, we have to deal with a different problem. Is such work really that of a scientist or that of an artisan? Certainly the mere testing of one brand of an arsenical against another is not a matter of science. Doctor Forbes has aptly said that such work "really stands for the most part fairly across the boundary line of horticulture and agriculture." We need further work upon the origin and perfection of insecticides, and this will require much true research, but is not this within the chemist's field and should it not be turned over to him with the cooperation of the entomologist, who will aid in the testing of promising products of the chemical laboratory? We need better spray pumps and other insecticidal apparatus, but had we not better leave their construction to our mechanics or employ mechanics specially for such work under the employ or with the cooperation of the entomologist? Is it worth while for us to spend time perfecting apparatus if we can avoid it, and even if necessary is it true research in economic entomology?

(4) In the control of insects by means of general methods of farm practice, including such methods as rotation, planting, cultivation, trap crops, immune varieties, etc., we meet with a similar problem. Is it the function of the entomologist to ascertain the very best way to grow a crop to avoid insect depredations, how much fertilizer to use per acre, how to apply it, what sort of implements to use, etc., involving all the questions of agricultural practice, or should we seek to produce or find varieties immune to insect attack? Many of us have been forced into such work. Should it not be done by our horticultural and agricultural colleagues with our cooperation, and should not a rational policy of station management so divide such problems that each of us will be working on that phase of the

problem for which he is specially trained, and not encroaching upon the field of another where often the entomologist may flounder around to the amusement of those to whom it naturally belongs? Most of us are unable to fathom all the depths of all branches of agricultural science. Should we then attempt research in these phases of economic entomology except in a cooperative way?

(5) Coming to the study of the natural agencies in the control of insect pests, we again come to fertile soil for research. (A) The study of parasites is fast coming to the front. The mere recording of certain parasites bred from certain insects is often of no practical importance, but when we come to consider the general ethology of parasites in relation to injurious insects and the possibility of their importation either for the possible effect upon the normal host or upon other hosts, we may be led to the very best type of research concerning them. The work of attempting to propagate hymenopterous parasites in sufficient numbers to be used commercially, now being attempted at the Texas College, in cooperation, I believe, with the Bureau of Entomology, is a most valuable experiment. The work of Mr. W. Dwight Pierce, recently described by him at a meeting of the Association of the Cotton Belt Entomologists, in studying the interrelations of the parasites of the boll weevil with the native hosts of those parasites and the food plants of their natural hosts, is a field of research well worthy the careful work it is receiving. Or consider the influence of climatic conditions upon parasites. How often have we observed an outbreak of an insect pest with a partial parasitism and wondered whether to advise remedial measures or to advise leaving its control to the good offices of the parasites? Would not a more accurate knowledge of climatic influences on parasites greatly aid in our prognostications in such a case? (B) Similar remarks might be in order in regard to the study of predaceous insects. We have still much to learn concerning their economic importance, and more particularly as to the best means of making use of them. (C) So far we must confess to rather poor results with fungi and bacteria used as artificial means of insect control, but they are undoubtedly large factors in the control of Nature. Here we must have the cooperation of the mycologist, but is there not room for considerable more first-class research along this line? Has the last word been said upon the control of insect pests by diseases? (D) And, finally, what do we really know as regards the effect of climate upon the mortality of insects? Prof. Wilmon Newell, with his experiment with 28,000 boll weevils last winter, will undoubtedly be able to give us much valuable data on this subject, but I think he will admit that he has but made a start along the right track. In this subject of the relation of climate to insect mortality and control we must needs make use of meteorology and probably

of physiological chemistry; but such research seems to lie more clearly within the province of the entomologist than of any of his colleagues, unless perchance he is so fortunate as to have a professional meteorologist connected with the Station, which seldom occurs, in which case such work might be carried on cooperatively to better advantage. We are doing something along this line in New Hampshire and trust that in a few years we may know something definitely as to the influence of climate on various phases of insect life and mortality.

Thus there are abundant opportunities for research of the highest order in entomology, strictly economic and related to agriculture. Pardon me for their lengthy enumeration. They have doubtless occurred to most of those present. But sometimes it is well for us to consider these matters definitely and in systematic fashion, and this paper has been presented merely with the hope that it may form the point upon which discussion and thought concerning this whole question may be brought to focus. Will not more research along the lines above indicated tend to more clearly define the exact province and scope of economic entomology? Indeed, will not such work be the making of a distinct science of economic entomology and be the means of giving it a scientific standing in the front rank of modern sciences, thus commanding and attracting the best scientific ability?

Mr. Hopkins emphasized the importance of investigators of economic problems generally devoting a considerable part of their time to the determination and verification of fundamental technical data on which to base authoritative conclusions. He also referred to the confusion in our economic literature due to the continued quotation of unverified statements. As an example, he had found, by study of anatomical details, that the white-pine weevil (*Pissodes strobi* Peck) is specifically different from two or three undescribed species heretofore confused with it, not only in structural characters, but in life history and habits. Therefore much of the literature, especially that relating to remedies, is practically valueless, because it was founded on facts relating to several species with different habits. He stated further that in order to make the best progress in economic work governing boards and the public must realize more than they have heretofore that the economic entomologist must first have an authentic identification of the species, based on a knowledge of the systematic and technical facts, before he can determine the best methods of combating the injurious or of utilizing the beneficial ones.

Mr. J. B. Smith gave a short statement of the many difficulties which surrounded the earlier entomologists, particularly those who attempted to carry on systematic work. He related some incidents showing the self-denial and perseverance of such men as Doctor Le Conte and Doctor Horn, and brought out the fact that if the work done by some of the older entomologists now proved defective, we should never lose sight of the poor equipment which they had and the many obstacles which they were obliged to overcome in order to do any work at all.

On request, Mr. Comstock gave a brief outline of the entomological work at Cornell. Both the Adams and the Hatch funds are being devoted to research. One assistant entomologist has been employed at a salary of $1,000 a year and $500 is held in reserve for his expenses. No teaching is required, and his entire time will be devoted to investigation. He stated that, in brief, future entomologists should be broadly educated.

Mr. Fernald gave as his opinion that it was now necessary for entomologists, particularly students who are expecting to make entomology their life work, to first become well acquainted with the fundamental principles of animal and plant life. The broader the man, as a general proposition, the better work he will be able to do.

Mr. Skinner agreed with the remarks of Mr. Smith, and cited a number of instances showing the extreme difficulties under which many of the older systematic entomologists worked.

Mr. Kirkland stated his belief that entomologists, particularly economic entomologists, should be familiar with business principles, and that many failed because they had little experience along this line.

The session then adjourned until 1.30 p. m.

AFTERNOON SESSION, SATURDAY, DECEMBER 29, 1906.

The meeting was called to order at 1.30 by President Kirkland, and the following paper was presented:

NOTES ON A NEW SAWFLY ATTACKING THE PEACH.

(*Pamphilius persicum* MacG.)[a]

By B. H. WALDEN, *New Haven, Conn.*

(Plate I.)

On June 11 of the past season we received a letter from one of the leading Connecticut fruit growers, stating that an insect had appeared in a peach orchard at Yalesville and was eating the young fruit. He described the insect as being very active, and about one-half an inch long, head black and white, much like that of a hornet, body brown or copper color, with rather large wings. He thought it the same insect that defoliated sections of the orchard the previous season.

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[a] This insect was described under the above name by MacGillivray since the presentation of this paper (Canadian Entomologist, Vol. XXXIX, No. 9, Sept., 1907, p. 308).—ED.

Being unable to identify the insect from this description, a visit was made to the orchard on June 14. It was found, as expected, that the common rose-chafer (*Macrodactylus subspinosus* Fab.) was eating the young peaches; but flying around among the trees were a number of sawflies which the owner pointed out as being the insects to which he had referred. Although not more than ten or twelve sawflies were seen around a tree, the owner stated that they were much more numerous a few days before. Some of these were caught to bring back for identification.

On examining the trees carefully, numerous eggs were found on the underside of the leaves along the midrib and usually on the basal portion of the leaf. These eggs were nearly white in color, about 1.6 mm. in length and 0.75 mm. in width. Some of these had hatched, and small greenish-white larvæ were feeding on the leaves. They eat a narrow section, beginning at the edge, and work toward the midrib of the leaf, then roll one of the corners over, thus forming a case within which they conceal themselves, as shown in the illustration (Pl. I, fig. 2). Some of this material was collected for rearing, but through neglect the larvæ all died.

The writer was unable to visit the orchard again until July 21. The larvæ had all disappeared, but the work of this insect was seen throughout the 80-acre orchard, though only in small sections were the trees badly defoliated. The owner thought that the injury was as severe as during the previous year, and that the insect had spread over a much larger area this season.

No remedy was tried against this pest. As peach foliage in Connecticut is usually injured by any spray, it seems to the writer that the most practicable treatment would be to keep the soil well stirred, especially near the base of the trees, for a few weeks after the larvæ begin to go into the ground to pupate. Spraying the ground around the trees with kerosene emulsion might also kill many of the larvæ.

It might be well to state that this is an old orchard, which was somewhat injured by the winter of 1904, and has not been cultivated as thoroughly as the owners usually cultivate their orchards.

Specimens of the sawfly were sent to Dr. A. D. MacGillivray, who pronounced it a new species. The female is about 9 mm. (three-eighths of an inch) long, with a wing expanse of 19 mm. (three-fourths of an inch). Head and thorax black, with pale-yellow markings. Antennæ about one-fourth of an inch long. Abdomen with two black basal segments, the remainder being brown-ocher in color. Legs with pale yellow femora, tibiæ and tarsi brown-ocher.

It is hoped that this insect can be studied another season and notes made regarding its life history.

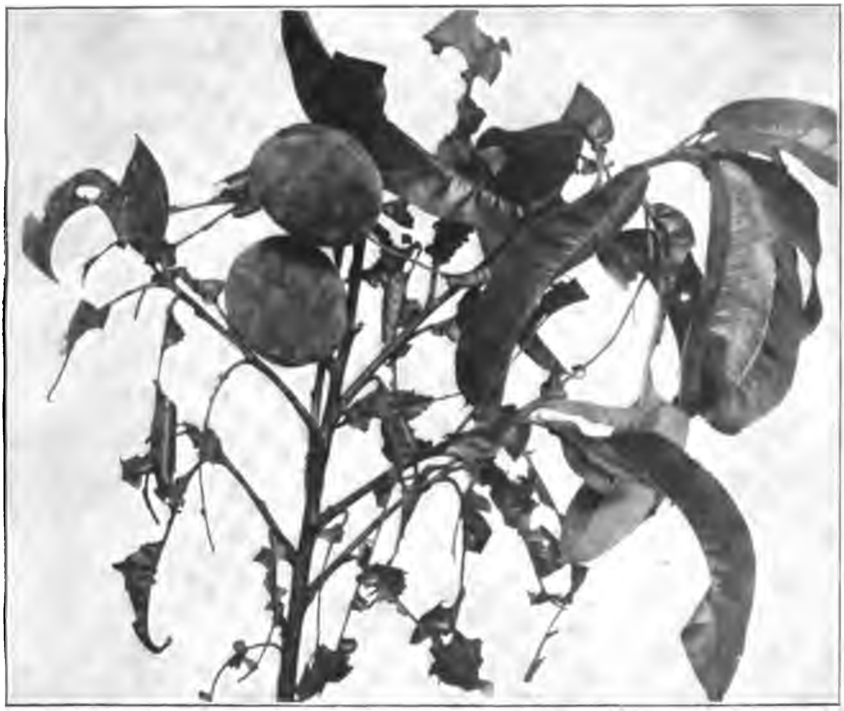

FIG. 1.—PEACH BRANCH, SHOWING HOW LEAVES HAVE BEEN EATEN BY LARVÆ OF THE SAWFLY PAMPHILIUS PERSICUM. (ORIGINAL.)

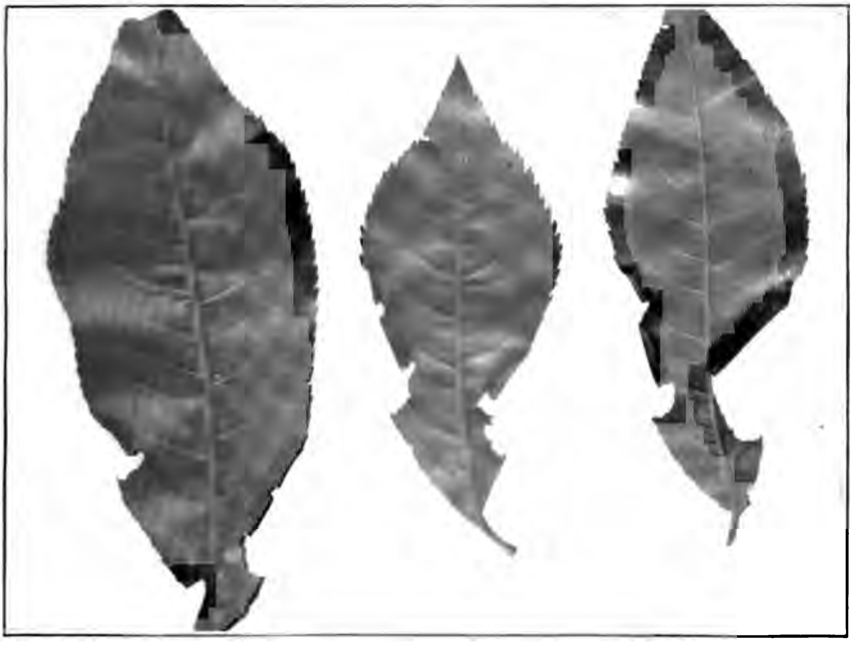

FIG. 2.—PEACH LEAVES ROLLED BY LARVÆ OF THE SAWFLY PAMPHILIUS PERSICUM. EGGS ON MIDRIBS NEAR BASE OF LEAVES. NATURAL SIZE. (ORIGINAL.)

Mr. J. B. Smith stated that this sawfly occurs in New Jersey, as he has found it at South Orange, and Mr. Titus reported finding it in Pennsylvania.

A paper was read, entitled:

ECONOMIC WORK AGAINST THE HOWARD SCALE IN COLORADO.

(*Aspidiotus howardii* Ckll.)

By E. P. TAYLOR, *Fort Collins, Colo.*

It is my opportunity to report the first economic work against a new and important fruit-tree pest, *Aspidiotus howardii* Ckll., which is doing great damage to orchard trees in parts of Colorado and other points in the West.

The insect has been previously reported in various entomological publications, but up to a short time ago has received little attention from an economic standpoint. Upon discovery of its injurious work in the orchard sections of western Colorado I was enabled to undertake economic experiments for its control, and it is upon these preliminary tests that this paper is based.

As an introduction I shall briefly treat of the history of the insect from its first discovery at Canon City, Colo., by Prof. C. P. Gillette, on August 31, 1894. These first specimens were taken by Professor Gillette upon the fruit of plum, and specimens were sent to both Dr. L. O. Howard and to Prof. T. D. A. Cockerell, then of the New Mexico Agricultural Experiment Station, but now of the University of Colorado. The former pronounced the insect an entirely new species, and Professor Cockerell, after study and comparison, introduced the insect as a new species, *Aspidiotus howardii* Ckll., in an original description published in the Canadian Entomologist, Volume XXVII, page 16 (1895). Professor Cockerell himself encountered the scale at Albuquerque, N. Mex., in August, 1895, upon the fruit of silver prune, which determination was again verified by Mr. Pergande, of the U. S. Department of Agriculture, from material furnished him.

Prof. Wilmon Newell contributed, in 1899, from Iowa, an article upon The North American Species of the Subgenera Diaspidiotus and Hemiberlesia of the Genus Aspidiotus, including Professor Cockerell's original description of *Aspidiotus howardii* and giving as its habitat Colorado and New Mexico.

The next mention we have of it is from Professor Gillette, of Colorado, in his Entomological Report for 1901, when he reports its occurrence for the first time upon fruit trees in western Colorado on the western slope of the Rocky Mountain range. The following year he reported its discovery upon the under surface of the leaves and upon the tender twigs of white ash shade trees growing upon the streets of Denver.

It may be stated that notwithstanding its occurrence upon shade as well as fruit trees it is primarily the pest of the latter. In my observations in Colorado this season I have taken the species upon pear, prune, plum, almond, and apple, and at elevations above sea level varying from a little over 4,000 feet to about 7,000 feet.

Injury from infestation follows from two sources, (1) the dwarfing and robbing of the trees of their sap substance, resulting in retarded growth and cracking of the bark, and (2) an unsightly pitting of the surface of the fruit itself, with more or less attendant discoloration about the points of scale attachment. In the case of yellow skinned plums these reddened blotches about the scale situs are most noticeable and objectionable. With dark-colored plums and prunes the scales appear as many small white specks scattered over the surface, and with the pear deep pits are found in the skin, some of these measuring nearly one-fourth inch deep and as wide across at the top. Bartlett pears are especially subject to attack, as are silver prunes, almonds, and wild goose plums. These varieties and some others when infested and allowed to go without spraying will in time become completely incrusted as in the case of the San Jose scale. Early descriptions of this insect gave it as a pest principally upon the fruit instead of the tree. The tendency to infest the fruit itself is perhaps greater than with other species of this genus, but the attack is also directed to bark, twigs, and leaves. A marked preference is shown for Grimes Golden apples, this variety becoming infested in orchards where all other varieties are exempt; in fact, Grimes Golden and Geneton are the only varieties of apples observed by me to be infested. By far the greatest injury, so far as my observations have extended, has been done to pear, and to the orchardist in certain sections it is popularly known as the " pear scale." From its variety of food plants the name Howard scale is more appropriate.

Though Colorado, so far as known, is entirely free from the San Jose scale, the life history and appearance of the scale has become more or less familiar to many of the more progressive orchardists of the State from literature published upon the pest. Upon the discovery of the Howard scale in injurious numbers, however, it was a natural mistake for them to assume the presence of the San Jose scale, and this was what occurred. The two are of rather close resemblance to the unpracticed eye, and both infest their host plants in about the same manner. Both are of the same genus and subgenus, Diaspidiotus. The Howard scale, however, carries a much closer resemblance to the Putnam scale (*Aspidiotus ancylus* Putn.) of maple and other trees than to the San Jose scale.

The female scale is circular and flat, about 1.5 millimeters in diameter or about the size of a pin head. It is pale grayish in color when matured, much lighter in hue than the partially matured or even the full-grown female of the San Jose scale. The scale exuvium in color is a dull orange when the secretion over it has been rubbed away, which is quite easily done. The female insect is broadly pyriform in shape. It belongs to that class of the genus Aspidiotus where the scales of the females are nearly circular, while those of the male are more elongate or nearly oval, though an examination of the female insect beneath the higher power lens is necessary to observe the typical second pair of large lobes at the caudal end of the female, which distinguishes it from that of the San Jose, Putnam, or other scales of its group. Its nature of attack and general appearance upon heavily infested trees are quite enough to enable ready recognition from others of these types. The pallidness of the female scale is quite characteristic, some individuals being nearly white.

At the beginning of my experiment with insecticides for the control of the pest, very little was known with certainty of the insect's exact life history. Observations, somewhat fragmentary, were, however, carried along through the season and some of the facts learned.

The first observations the past spring were begun upon March 19, at which time some females were found well grown and of pale gray color. Others among these were smaller in size, some circular and some oval in outline. All these smaller-sized scales at the date mentioned showed a whitish area in their center surrounded by an area much darker and in certain cases of a dusky gray. In the center of the white area, which occupied about one-third of the surface of the scale covering, a small whitish nipple was seen surrounded by a rather shallow or indistinct ring or furrow. On account of the weathering of these scales most of them showed reddish or orange-colored centers. Out of a large number of scales counted, about 31 per cent were found to contain no living insect, representing the average rate of mortality from natural causes. Some of the dead scales were the result of parasitism by insects which were observed later in the season, while others were dead from exposure to the winter climate.

The oval male scale is much darker in color than the female. These oval male scales were found to yield adults as early as April 30, at which time several winged specimens were seen in process of fertilizing the matured scales which had lived through the winter. The males are of very minute size, pale brown in color, with black eyes. Early in June many young scales were beginning to appear, crawling over the surface of the bark in much the same active manner as the young of the San Jose scale. By June 9 many had settled down, and the bark was thickly covered with this early summer brood. Some were seen upon both upper and lower leaf surfaces and many at this date had well-developed scale coverings already secreted over them. Many oval eggs were found, showing the females to be oviparous rather than viviparous, as in the case of its close neighbor, the San Jose scale. The exact time required for hatching is evidently quite short, for beneath these female scale coverings and along with the small clusters of eggs are usually also to be seen the minute yellowish-orange-colored and newly hatched young. In western Colorado it is probable that at least three and perhaps four broods are developed throughout the season, including those living through the winter; and male insects are seemingly produced throughout the greater part of the summer season.

Early in June and again in the month of August adults of an interesting hymenopterous parasite were observed; specimens were determined as *Prospalta aurantii* How., which, according to Doctor Howard, is entirely new to this species. The adult parasites emerging left the small round circular apertures which I found in the centers of so large a percentage of the larger scales through the spring and summer. Adults and larvæ of the more common lady beetle, *Chilocorus bivulnerus* Muls., also played some part in the destruction of the scale.

A survey of the orchard section of western Colorado showed the scale's distribution to be quite general. The growers about the region of Grand Junction have thus far been most successful in withstanding the usual destruction occasioned by pear blight, accounting at this time for an extensive pear acreage. At this place the spraying experiments were carried out and upon pear trees previously unsprayed and consequently badly incrusted with the scale at the outset of the tests.

In all about 200 pear trees were included, and the insecticides used were principally those known to have been more or less successfully used against the San Jose scale. The sprays and their formulæ were as follows:

(1) "Rex" lime and sulphur dip, diluted 1 to 11 with cold water.

(2) "Rex" lime and sulphur dip, diluted 1 to 8 with cold water, with 15 pounds lime added per 50 gallons of spray.

(3) Lime-sulphur-soda wash, prepared without use of external heat and boiled by the soda and heat of the slaking lime—30 pounds lump lime, 15 pounds sulphur, and 5 pounds caustic soda per 50 gallons of water.

(4) Lime-sulphur wash, prepared in usual way by boiling 45 minutes with external heat, and composed of 15 pounds lime and 15 pounds sulphur per 50 gallons of water.

(5) Kerosene emulsion, 20 to 30 per cent kerosene, prepared with the use of slaked lime.

(6) The patent soluble petroleum spray "Scalecide," used with a 5 per cent dilution in cold water.

(7) "Chloroleum," a new commercially prepared creolin spray, used also with a 5 per cent dilution in cold water.

Both spring and fall applications were made with most of these preparations, the spring sprayings being given April 5 and 6 and the fall treatments on November 7.

Without going into the details of the experiment, it may be stated briefly that the lime-sulphur washes were most successful when cost and efficiency were considered. Comparing the results of my work against the Howard scale with my experience with the San Jose scale in Illinois, it was quite evident that the Howard scale was the more easily controlled. Examination of the structure of the scale covering protecting the Howard scale explains, perhaps, the cause of its greater susceptibility to contact sprays. With the Howard scale the coverings are much more loosely attached to the bark. This gives the spray less resistance in coming into direct contact with the body of the insect concealed beneath.

All of the lime and sulphur preparations were effective. "Chloroleum" did not promise well as an insecticide for this purpose and almost a complete failure was made in attempting to prepare the kerosene emulsion with the use of lime. A dry, finely slaked lime, discarded as a by-product from a local sugar factory, was used, which may have been the cause of its failure. The lime failed completely to properly absorb the oil, and when an attempt was made to agitate the mixture by forcing through a force pump the thick, doughy mess completely clogged strainer and nozzle.

"Scalecide," on the other hand, gave much promise. It was sprayed in November and consequently the final results are yet unknown. It must be said, however, that the soluble petroleum sprays are most deserving insecticides from the standpoint of both effectiveness and convenience of use, and could their cost and transportation expense to the West be lessened they would receive more universal use by orchard men.

As stated, the lime-sulphur washes were found best adapted for combating this new scale pest. The self-boiled mixtures and those boiled by caustic soda in the experiment were not so satisfactory as the ones prepared by boiling properly, but the inconvenience of cooking creates a certain demand for a material ready made and possible of immediate dilution with cold water. The "Rex" lime-sulphur used in the experiment was of the latter class. It is a concentrated lime-sulphur solution formerly used in the West as a stock dip and first used in the Middle West against the San Jose scale by Professor Forbes in Illinois. The following comparison shows it slightly less effective than the orchard-boiled lime and sulphur wash, but successful enough to justify use under special conditions, and presents in brief a comparison of the "Rex" lime-sulphur wash and the homemade lime-sulphur spray as used in this test against the Howard scale of pear.

Spray.	Formulæ.	Date sprayed.	Percentage of scales dead at examination, April 25.	Percentage of pears infested at picking time, August 17.
"Rex"	"Rex," 1 part; cold water, 8 parts. (Lime, 15 pounds per 50 gallons.)	April 6	84.4	2.8
Lime and sulphur	Lime, 15 pounds; sulphur, 15 pounds; water, 50 gallons; boil 45 minutes.	April 5	93.8	.6
Check	Not sprayed		55.0	96.1

Two means of comparison are to be had in the above table, the first as indicated in the count of the percentage of scales dead upon the bark of the tree upon April 25, at which time the Rex lime-sulphur gave 84.4 per cent dead, the lime-sulphur wash 93.8 per cent dead, and the plat given no spray 55 per cent scales dead of those counted. As will be noted, this count was made only twenty days following spraying, and a later examination would have yielded a higher percentage killed in both of the treated plats, due to longer action of the adhering spray.

The second means of comparison, and that of more practical bearing to the fruit grower, is shown in the table as a count of the percentage of pear fruit showing the pits from infestation, found on the surface in a count made on August 17, at time of harvest. This comparison shows but 2.8 per cent pears infested upon an average borne upon the tree in the plat sprayed with the Rex. The lime-sulphur plat gave 0.6 per cent infested pears or less than one per 100, while the check or unsprayed trees gave 96.1 per cent infested. In each case many hundreds of pears were counted in securing these ratios. They show good results with both sprays, but a slight advantage with the orchard-boiled mixture. It was also apparent that pears borne upon badly infested trees not treated would almost without exception show infestation sufficient to exclude them for market purposes.

With one proper dormant spray of lime-sulphur wash, it is shown that the Howard scale may be controlled, and, unlike the San Jose scale, it seems probable that one spraying in two years will accomplish this result.

The first spraying at Grand Junction against this pest was done with whale-oil soap. In one orchard observed at that place it was reported that three years ago over $1,000 worth of fruit was rejected by the inspector of a local fruit growers' association on account of the pears being rendered unsightly by scale pits and blotches caused by the insect, aside from the dwarfed tree growth and cracked condition of the bark. The year following this a thorough spring spraying with lime-sulphur wash reduced the injury to tree and fruit to a point beneath practical notice. The treatment was repeated last March, with the remarkable result that of a crop of 2,200 boxes of choice and fancy pears packed this fall only 2 pears were encountered bearing scales. Last spring in the orchard section for a few miles surrounding Grand Junction, one of the fruit districts of western Colorado, 40,000 pounds of sulphur were used by the members of a single fruit growers' association, principally against the Howard scale of the pear, besides a carload of 30,000 pounds of the "Rex" lime and sulphur concentrate introduced as an experiment.

This season these same growers will consume a greatly increased amount of sulphur, and have already placed their order for 5 carloads of the "Rex" product, aggregating over 400 barrels of the concentrate, sufficient when diluted with 11 times its volume of water, to produce 4,400 barrels of spray. As a rule this will be applied with gasoline power-spray outfits, nearly 200 of which are owned and operated in the orchards about this one point mentioned.

Economic entomology is enthusiastically practiced by the progressive fruit growers of Colorado, and well it may be when her fancy grade lime-sulphur sprayed Búerrē de Anjou pears net the growers $5.10 per box, as they have done this season when placed upon the New York City market.

In reply to an inquiry, Mr. Taylor stated that the Howard scale was found on native trees, such as white ash, also on apple and plum. He considered it quite a serious pest and that it might possibly be shipped out on nursery stock. The danger, however, was somewhat remote, as no stock was shipped east from Colorado.

Mr. Titus remarked that this insect was probably a species native to Colorado, as he had found it on native wild plum.

Mr. Taylor stated that most of the spraying in Colorado was done with gasoline spraying outfits, and that each outfit would cover about 20 acres of bearing orchard. He had used the Rex lime and sulphur mixture with fair results. It was sold in Colorado for $12 a barrel.

A paper was presented, as follows:

THE MAPLE LEAF STEM-BORER.

(*Priophorus acericaulis* MacG.)

By W. E. BRITTON, *New Haven, Conn.*

[Withdrawn for publication elsewhere.]

The following paper was read:

THE VALUE OF PARASITES IN CEREAL AND FORAGE CROP PRODUCTION.

By F. M. WEBSTER, *Washington, D. C.*

While there has been much said of late concerning the beneficial influences of parasites in affecting insect pests of the orchard, garden, and truck farm, we hear little of this in relation to such as attack grain and forage crops. It might almost be said that the average farmer, from his point of view, sees only the benefits derived by the fruit grower, while the aid that he himself receives from the good offices of parasites is quite outside his vision. The facts are, however, almost if not quite the reverse, and it is probable that the crops of the average farmer are more continually under the protection of, and greater losses are prevented by, beneficial insects than in any other field of husbandry. The real difference is that in the case of the farmer they are obscured or overlooked; while among the fruits and vegetables, where observation is less difficult, much more that transpires is seen and recorded in reports, bulletins, and the agricultural press. A case in point from my own observation many years ago will serve as an illustration.

There was a threatened outbreak of wheat midge (*Contarinia tritici* Kirby) in a field of wheat, the larvæ at the usual season being excessively abundant. During late afternoons and early forenoons the heads of wheat were visited by great numbers of predaceous insects that hunted about among the bracts, and greedily devoured the larvæ of the midge. Day after day this was observed, until it seemed to me that none of the victims could have escaped capture. Gradually and naturally the heads changed from green to golden, and the threatened disaster did not materialize, there being very few of the midge larvæ remaining in the heads, where a short time before there had been myriads. To me, who had watched the proceedings daily, it was clear that the crop had been saved from serious damage, if not, indeed, a loss so great as to render the field of too little value to harvest. One day at harvest the farmer himself was observed standing with a neighbor near the borders of his field, and I caught a few words of his conversation as I passed by, to the effect that his success in wheat growing that year had been due to good farming. I asked him if he had noticed any insects on the heads of his wheat, and he gave me most conclusive proof to the contrary by stating that he had never looked to see if there were any there, but he thought not.

Another case in point will be appreciated by those who are familiar with the actions of the Hessian fly and its parasites. A field of wheat in northern Indiana back in the 80's was so seriously affected by the fly in the fall as to render the outlook for the owner getting even his seed back at harvest exceedingly dubious. With the coming of spring the wheat plants, or rather the belated tillers thereof, sprang up and the owner harvested a crop of 20 bushels per acre. There was almost no infestation of fly in spring. Now for the reason for this seemingly supernatural phenomenon. In fall I had taken the precaution to collect a quantity of dead wheat plants from this field and placed them in breeding in a warm room. Very few flies were reared, but swarms of *Polygnotus hiemalis* Forbes emerged from the "flaxseeds" ensconced among the dead wheat plants. I now know that of that yield of 20 bushels per acre secured from this field not less than 18 bushels per acre should go to the credit of Polygnotus. This was the year following Doctor Forbes's description of his *P. hiemalis*, and none of us at that time knew much about it. More than ten years after, in another State, almost a parallel case was presented. This time, however, a most perplexing matter developed. The infested wheat was of a variety that persons with seed to sell were endeavoring to boom, and one of the virtues claimed was immunity to attack of the Hessian fly. Although I reared fully 100 Polygnotus to one fly from the dead plants in the fall and knew absolutely that the parasite saved the crop by sweeping the fly almost out of existence, yet I found both myself and the Polygnotus alike discredited and the claim set up and sustained that the whole thing was due to certain virtues possessed by this particular variety of seed wheat, for which a fancy price was demanded and obtained.

Within the last two years, in a section where spring wheat only is grown, we have found a similar condition existing, and all facts so far obtainable go to show that but for the efficient aid offered by Polygnotus spring-wheat growing in the Northwest would cease to be profitable. These minute insect parasites save the country millions of dollars, yet they are unknown except among entomologists.

Again, Dr. Paul Marchal, who studied the development of *Polygnotus minutus* in France, but did not witness oviposition, states that there is every evidence of polyembryonic development, the egg being deposited in that of the Hessian fly and hatching in the body of the maggot of the latter after it has left the egg. That is to say, there may be several germ cells within a single ovum, and consequently several larvæ may develop from a single egg. We have not by any means cleared up the obscurity relative to an American species, though all of my assistants have repeatedly observed the female Polygnotus ovipositing in the eggs of the Hessian fly, and Mr. G. I. Reeves has found larvæ to the number of 28 in the matured maggot. We have thus observed the oviposition in eggs of the fly and reared adults from the "flaxseeds." If Doctor Marchal's suppositions are correct, and, as is very probable, our American species have similar habits, their economic importance will be immense, for it will be possible for a single female Polygnotus to place her supply of eggs singly in those of the Hessian fly, and the number of her progeny would be limited only by the sustaining capacity of the host larvæ.

Another parasite with polyembryonic development is *Platygaster herrickii* Pack. Mr. Reeves has observed this also, ovipositing in the eggs of the Hessian fly, and at another time, in a locality several hundred miles distant, he counted over 40 larvæ in a single maggot.

Whether or not there are other species of Platygaster infesting the Hessian fly it is just now impossible to state, but there are certainly more than one species of Polygnotus engaged in this efficient work, and the saving to the wheat growers of North America through their influences is immense.

The whole problem of polyembryony among parasitic insects is exceedingly interesting and of the utmost economic importance. When Doctor Howard called attention to the enormous numbers of Copidosoma that he had reared from a larva of *Plusia brassicæ* in 1882, the number from a single individual, of 19 larvæ, being 2,528, he was unable to learn by dissection that the female Copidosoma was capable of laying more than 160 eggs. Later, in Ohio, I reared from a lot of 5 larvæ of this species the enormous number of over 4,800, and since that time Mr. C. W. Mally, in South Africa, reared 2,112 from a Plusia larva, while Monsieur E. Bugnion has reared over 3,000 individuals from a single host larva. Doctor Howard first thought that more than one female Copidosoma had oviposited in a single host larva, but this has since been found to be exceedingly unlikely. In the case of some of our American species of Polygnotus and *Platygaster herrickii* the female parasite positively refuses to oviposit in eggs that have already been visited by another female. Attention has also been called to the almost general phenomenon of all individuals from a single larva being of the same sex, all of which goes to imply that but a single ovum is placed in a single host, and the extent to which the parasitic larvæ will multiply from this is only limited by the size of the host larva. Thus we have an explanation of what has been a puzzle to entomologists, viz, the sudden and almost complete disappearance of the Hessian fly between broods. It also indicates the great value of these insects for use in introducing parasites in sections where an outbreak of the host insect is seemingly impending. How many of our parasites have this polyembryonic development we do not know, but where we rear such an abnormal number of parasites from a single host, and those from a single host are all of the same sex, the case will at least bear investigation.

These parasites have, however, one weak point. A sudden disaster to their host reduces them almost to the verge of extermination. For instance, over a considerable portion of the central Pacific States during the past autumn there was so much rain just prior to seeding time that the ground could not be prepared for wheat sowing until late. Hence there are but few of the fly even in the earliest sown fields, thus reducing the food supply of these parasites to the minimum and preventing their breeding in any considerable numbers.

There is another group of parasites of the Hessian fly whose habits are normal, but which have a greater number of host insects. Among these may be placed *Eupelmus allynii* French. This species ranges from New England to Montana, south to South Carolina, Georgia, and Texas. The insect has two advantages in that it is double brooded and is also a parasite of the several species of jointworms (Isosoma) that work in wheat, rye, and cheat, thus being present among these grains whether infested by the Hessian fly or not. We also rear it from Isosoma-infested timothy, orchard grass, quack grass, Muhlenbergia, Elymus, and in the West from Bouteloua, Stipa, Sporobolus, and *Hordeum jubatum*. So, while this parasite does not increase as rapidly as Polygnotus and Platygaster, it has the advantage of not being so dependent upon a single host for sustenance. This double-brooded feature is also found in *Semiotellus* (*Stictonotus*) *isosomatis* Riley, *Semiotellus chalcidiphagus* Walsh and Riley, and *Websterellus tritici* Ashmead, parasites of single-brooded jointworms, but not, so far as is known, of the Hessian fly.

Turning to the parasites of Isosoma, we find here also illustrations of the value of parasitism. While there are a few species that we expect to breed from the larvæ of any or all of them, there are others that seem to be restricted to a single species. As an illustration, we rear an undescribed species of Cryptopristis from *Isosoma tritici* Riley infesting wheat, but in over 400 rearings of Isosoma we have failed to get it from any other host. Its area of distribution is not that of *I. tritici*, however, as it seems to occur only from New York to Virginia, Kentucky, and eastern Illinois. This is also two brooded, while its host is single brooded, and from the enormous numbers that emerge from wheat stubble infested by the Isosoma larvæ, sometimes in the ratio of 35 or 50 Cryptopristis to one of the Isosoma, it will be seen that they are no small factor in holding the pest in check. But here, again, the entomologist does not know enough about it to be certain whether or not it is described, and the farmer is ignorant of its existence.

In the case of a species of Isosoma seriously affecting timothy, we have almost a parallel case, as we rear with it an undescribed species of Websterellus from New England to Tennessee and west to the Mississippi River, the absence of Isosoma apparently increasing and decreasing in proportion to the abundance of the parasite. As the pest decreases the yield of timothy seed from 5 to 18 per cent, and injures the hay crop as well, it will be seen that the parasite is, to a certain extent, saving the property of the farmer.

Take as another illustration the army worm (*Heliophila unipuncta* Haw.), which we know does not occur destructively in the same locality two years in succession. Anyone who has watched an outbreak has hardly failed to observe the havoc wrought by one or more species of tachinid flies. I remember distinctly an outbreak years ago in Indiana, where immediately after the outbreak of the army worm the fields were literally swarming with these flies, and the hum of their flight, as they flew about among the stubble and grasses, reminded me of bees. With a single exception, in the last twenty-five years, I have never observed an outbreak of this pest without these useful insects being present in abundance.

Perhaps the most serious insect pests of the arid regions, where irrigation is followed by alfalfa culture, are the several species of grasshoppers, and scarcely a year passes that numerous complaints do not come to us of their depredations. One of the most common species involved is *Melanoplus differentialis* Thos. Under date of August 7 a report was received from Fort Laramie, Wyo., stating that large numbers of these grasshoppers were dying and clinging to the alfalfa and weeds, over an area of about 6 acres. The material received was a mass of dead, disintegrating, and decaying bodies of this species of grasshopper, thickly populated with maggots from which *Sarcophaga georgina* Wied. was reared. Clearly it was this fly that had caused the mortality among the grasshoppers. June 6, previous, a similar complaint had been received from Lakin, Kans. In this last case the statement was made that in some instances over patches of nearly an acre, in an alfalfa field, the plants were literally covered with dead grasshoppers. While the grasshopper problem is not now, nor is it likely to be, settled by this species of Sarcophaga, it is clear that the restraining influences of these dipterous parasites are great; and we are not in a position to say what the grasshopper situation might not be if the parasites were not present.

The phenomenon that is most likely to attract the attention of the ordinary farmer is that of cutworms being devoured by Calosoma larvæ. I judge this to be the case from my own experience in connection with entomological correspondence, as there is hardly a year during which cutworms are especially numerous when our attention is not called to the matter by letters from farmers who have observed cutworms to be attacked and eaten by their black enemies. Sometimes it is clear that a serious attack of cutworms is prevented or decidedly lessened in this manner. I distinctly remember, years ago, when there was a severe outbreak of the grain aphis *Macrosiphum granaria* Buckton in Indiana. After the wheat in badly infested fields was harvested and in the shock, standing with one of these shocks between me and the late afternoon sun I could see the emerging parasites swarming in the air just about and above the cap sheaves. A farmer might see them, but to him they would be nothing but "pissants." There is hardly an entomologist who has attempted to rear adult insects from the larvæ who has not failed again and again by reason of the presence of parasites.

Now, I wish to submit that the causes and effects in all of these phenomena are always present; whether they are observed or not does not in the least alter the situation. The more light we can get on the actions, habits, and life history of parasites the better we shall be able to utilize their force in applied agriculture. The forces of Niagara Falls ran to waste for ages because no man understood how to conserve and apply this power. The forces of insect parasitism are, clearly, not *all* going to waste in this manner; but we are too ignorant of this force or how best to apply it in agriculture to derive more than the crude benefits that naturally follow its primitive influences. How much might this power be improved and directed if we only understood how to do it! To the ordinary farmer, at the present time, it apparently makes little difference whether the development of a parasite is polyembryonic or otherwise; whether it is dimorphic or not. But we can never hope to put him in the way of deriving the greatest benefit from the interaction of parasites and hosts until we have sifted this matter over and to the bottom. Indeed, we shall not know ourselves how to search for and control this immense, natural, powerful element until we have done this. In the past we have perhaps been too much like the medical practitioner, who gave his patient not the treatment that he should have had for his well being, and it might even be detrimental, but that which tasted best and was the most pleasing. The patient, in return, eulogized the doctor, paid him a round fee, and told him what a great man he was, which was, of course, sweet and pleasing to that sort of a man of pills and capsules. There has been altogether too much of this interpolated into agricultural science already, and some one, perhaps at the risk of becoming temporarily unpopular among the unscientific, must accept the trust and work out such obscure problems from the beginning, securing for those who may or may not understand the best and most that is to be derived from a knowledge to be gained only by thorough painstaking investigations.

This paper was followed by a general discussion, which was participated in by Messrs. Titus, Fletcher, Hopkins, Bishopp, Kirkland, and others. It proved to be of exceeding interest to all present and served to show the value of thorough and careful investigation of problems which are not given the attention they deserve.

Mr. Webster added two interesting facts relative to *Isosoma tritici*. In the past it had always been thought necessary, as a precautionary measure, to burn the infested bits of hardened straw that break up in thrashing the wheat, many being carried out with the grain instead of going over in the straw. Several experiments in rearing adults from large numbers of these broken bits of straw, collected about elevators and threshing machines, has shown that almost all of the larvæ of both Isosoma and parasites are killed, probably by the concussion of the cylinder of the thresher. In some cases we have been able to verify these experiments by collections of stubble from fields in the vicinity of these elevators. So far as we have gone into the investigation everything indicates that the danger from these broken bits of hardened straw, or even the straw itself, is of too little importance to be worth consideration. Prof. R. H. Pettit, of Agricultural College, Mich., and also one of Mr. Webster's own assistants, Mr. W. J. Phillips, in northern Indiana, have this year (1906) found great numbers of straws affected by the jointworm, where the enveloping sheath has been torn away and the galls formed by the larvæ deftly eaten away and the jointworms missing. In no case is the entire gall gnawed away, but just enough of the walls immediately over the larva to make possible the removal of the latter (fig. 5). While we have not been able to get definite information as to the identity of this decidedly beneficial animal, suspicion seems to point to the short-tail shrew (*Blarina brevicauda*) as the species to which credit should be given, and probably much of the work is done while the grain is in shock.

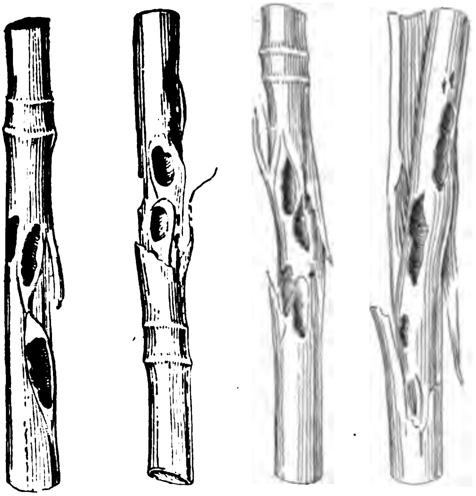

FIG. 5.—Wheat straws injured by the jointworm (*Isosoma tritici*) from which the jointworms have been removed by some beneficial animal, perhaps the short-tail shrew (*Blarina brevicauda*). (Original.)

A paper was presented as follows:

SOME GEORGIA INSECTS DURING 1906.

By R. I. Smith, *Atlanta, Ga.*

The year just closing has not been notable for any particular outbreak of insects, though certain crops have suffered more than commonly from the attack of common species. By that I mean that the weather conditions were favorable to the development of many field crop insects, such as the cotton bollworm, harlequin cabbage bug, army worm, corn weevil, and others. The record of insects of the year attacking staple crops is, however, much less interesting than that of last year.

COTTON INSECTS.

The bollworm (*Heliothis obsoleta* Fab.) was reported from Mitchell, Houston, Coffee, Lowndes, Baldwin, and Madison counties. Our correspondent from Valdosta, Lowndes County, reported his cotton damaged to an extent of nearly 90 per cent. It may be of interest in connection with bollworm injury to state that the feeding holes of the worms were in many instances the forerunners of anthracnose, a disease which caused the loss of thousands of bales of cotton in Georgia this year. Except for being an aid to the entrance of the anthracnose disease we do not believe that the bollworm caused its usual amount of damage.

The cotton leaf-worm (*Alabama argillacea* Hübn.), strange to say, was not once reported during the year. This meant that it did very little, if any, actual damage, but not that it did not appear. We are not so fortunate as to have become entirely rid of this insect.

The cotton aphis (*Aphis gossypii* Glov.) was present as usual on the young cotton.

Luperodes brunneus Cr., reported from Georgia last year at the meeting at New Orleans as the new cotton beetle, appeared again this season, but not in such great numbers. This insect was discovered at Lyons, Tatnall County, in a 10-acre field, and at Woodstock, Cherokee County, both reports coming in on July 9.

Chalcodermus æneus Boh., the cowpea-pod weevil, was first reported from Statesboro, Bulloch County, on May 5, its earliest reported occurrence in Georgia. Our correspondent stated that young cotton was being destroyed by this insect as fast as the plants appeared above ground. Specimens from Metter, Bulloch County, were reported as ruining young cotton in a few days. Specimens were also received from Emanuel, Randolph, Berrien, and Clay counties. In nearly all instances the weevil was present in cotton fields following a crop of cowpeas. Rotation would undoubtedly prevent most of the damage caused by this insect, so far as cotton is concerned.

Euphoria melancholica Gory and *Euphoria sepulchralis* Fab. were found eating into cotton bolls, probably after the latter became injured by the anthracnose disease.

Pissodes strobi Peck and *Aramigus fulleri* Horn were collected in cotton fields, both being mistaken for the boll weevil by the farmers who collected them.

Carpophilus dimidiatus Fab. was frequently found in rotting cotton bolls, and *Conotelus obscurus* Er. was discovered feeding in a cotton bloom, evidently having emerged from a rotting cotton boll.

GRAIN AND GRASS INSECTS.

Mayetiola destructor Say, the Hessian fly, seems to have been less abundant than usual in the wheat fields. This condition is due largely to the fact that heavy and continuous rains prevented the sowing of wheat early in October, when the first fields are usually sown. Our observations show that wheat sown after October 15 is comparatively free from the fly in ordinary seasons. Volunteer wheat which came up during the past August and September was in nearly all cases found badly infested.

The jointworm (*Isosoma tritici* Riley) is present in wheat and certain grasses, but has not been studied in Georgia.

Sitotroga cerealella Oliv. was found in stored wheat at Austell, Ga. An interesting occurrence in connection with this record is that practically all the grain moths were killed by the parasite *Pediculoides ventricosus* Newp., which was found in countless numbers on the wheat and on the floor of the building where the grain was stored. A complaint came to us that some insect of almost microscopic size was very annoying to the persons who had the handling of the wheat. Upon investigation the trouble was found to be due to the parasite just mentioned. The grain moth was found also at Cornelia infesting stored corn.

Laphygma frugiperda S. and A., the fall army worm, was perhaps the insect that caused the greatest popular alarm in Georgia during 1906. On July 18 we investigated damage to corn at Cartersville, Bartow County, and found it to be the work of this army worm. The cornstalks were frequently eaten into in a manner resembling the work of the corn stalk-borer (*Diatræa saccharalis* Fab.). In fact, when we first received a report by letter we supposed the trouble must be caused by the latter insect. Young corn about knee-high was eaten down almost completely, and larger corn damaged severely. It was learned that the worms first appeared in a grass field, from which they migrated to the corn. One field of cotton near Cartersville was damaged slightly. This army worm was next reported on August 4, from Pinehurst, Dooly County, where it was devouring grass and cotton—several fields of the former and one of the latter. Cotton was attacked in a peculiar manner. The leaves were not injured materially, but the young squares were devoured, and the worms had eaten into young bolls, destroying them completely.

This army worm appeared over considerable areas of grass fields at Albany, Vienna, and Americus. At Albany it was learned that the worms first became noticeable about August 1, and nearly all disappeared by August 10. My assistant, Mr. Lewis, who investigated the outbreak at all of the points mentioned, found great numbers of pupæ on August 14, from which adults emerged a few days later. The greatest injury caused by this insect in any one locality was at Albany, where 60 acres of grass were destroyed. The total loss in the State amounted to several thousand dollars. Cowpeas were injured slightly at Albany.

No other important insects of grain or grass have been reported or observed, except the usual cutworms and the white grubs attacking the roots.

FRUIT-TREE INSECTS.

Aspidiotus perniciosus Comst. was quite well controlled last winter and spring wherever lime-sulphur wash was properly applied. The soluble oil preparations have been used as a remedy with more or less success. Their value for Georgia conditions has not yet been fully demonstrated, though we feel certain that a strength greater than recommended by the manufacturers must be used to insure success. We have recently seen good results following the use of Scalecide at strengths of 1 to 10 and 1 to 12. The other soluble oil preparations have all been used in experiments made at Fort Valley during last October and November.

Scolytus rugulosus Ratz., *Sanninoidea exitiosa* Say, *Anarsia lineatella* Zell., and *Conotrachelus nenuphar* Hbst. all did about the usual amount of damage during the past season. The last named, the plum curculio, is undoubtedly an important factor in connection with brown rot of peaches. Nearly all the first rotten fruit is stung previously by the curculio, and it seems certain that the ruptures in the skin made by this insect offer a favorable entrance for the brown-rot fungus.

Aphis persicæ-niger Sm. on peach foliage was reported as being quite injurious at Kensington, Silver Creek, and Augusta, Ga. Tobacco decoction was found to be the most effective remedy for this insect. We have not received any reports of occurrence of the root form of this aphis.

Diplotaxis frondicola Say was discovered at Cave Spring, Floyd County, eating foliage from June-budded peach stock.

Saperda candida Fab. and *Chrysobothris femorata* Fab. have caused some damage to apple orchards, but on account of the small number of apple orchards in the State these borers are not given sufficient attention.

The codling moth (*Carpocapsa pomonella*) has been the basis of some experimental work by the board of entomology in Georgia this past season. Our life history study, carried on by W. V. Reed, has shown quite conclusively that we have only two broods of this insect in Georgia. Our spraying experiment failed for lack of sufficient infestation in the orchard selected for the experiment.

Aphis mali Fab. causes great damage to young apple orchards and also in the nursery rows. Kerosene emulsion as it is commonly prepared has not been found to be a reliable remedy. Tobacco decoction has given better results.

Hoplia trivialis Har. destroyed opening buds of Japan plum at Adairsville. Specimens were received April 12 with a report that the beetles were preventing the better portion of a good-sized tree from putting out foliage. The buds were eaten out close down to the base.

The woolly aphis (*Schizoneura lanigera* Hausm.) still continues to be one of our worst apple pests. As I reported last year, we have successfully killed the root form by application of kerosene emulsion. It may be of interest to state here in advance of a bulletin which we hope soon to publish that 10 and 15 per cent kerosene emulsion have been used without injury on roots of apple trees from 2 to 10 years of age. We injured 2 trees by an application of 40 per cent emulsion, but have not observed any injury from lesser strengths, not even from 30 per cent, which was tested. We would, however, consider it unsafe to use over 20 per cent emulsion and 10 or 15 per cent seems to be amply sufficient. The aerial form of woolly aphis is best controlled by tobacco decoction.

GARDEN INSECTS.

Without giving a list of all the insects injurious to garden crops I wish to say that these pests have been rather more than commonly abundant, their increase being due, perhaps, to weather conditions. Harlequin cabbage bugs, cabbage worms, cutworms, aphides, squash bugs, etc., were very much in evidence during the past summer.

SHADE AND FOREST TREE INSECTS.

Hyphantria cunea Dru., the fall webworm, appeared in great numbers during August and September in a considerable portion of Georgia. In Columbia County I observed nests on September 4 on persimmon bushes that had been entirely stripped of foliage. In that county it looked as though every persimmon bush and tree was inhabited by the fall webworm. Many farmers stated that this pest was more abundant this year than for many years past.

Datana integerrima G. and R. was found early in September in great numbers on a walnut tree in the city of Atlanta.

Saperda calcarata Say, the poplar borer, was found early in September severely injuring poplar trees at Lumpkin and Columbus. We were unable to breed specimens, but the samples of their work seemed conclusive evidence of the identity of this species.

Sesia tepperi Hy. Edw. and specimens of maple bark showing the work of the borer were received from Cordele on April 14. At that time we received 1 larva and 2 pupæ. Later we got more material, but only succeeded in rearing 1 adult, which emerged May 8. The injury to one maple tree was quite severe. Concerning the extent of injury on neighboring trees, we were not able to learn anything definite.

Pulvinaria innumerabilis Rathv. was discovered in small numbers May 1 on linden trees in Atlanta. At this date the egg sacs were fully developed, but no young were crawling. After being carried to the office the eggs commenced to hatch, about May 10.

Pulvinaria acericola W. and R. on sugar-maple leaves was received May 22. The egg sacs were numerous enough nearly to cover the leaves.

A plant-bug (*Neurocolpus nubilus* Say) was found May 1 in great numbers on two linden trees in Atlanta. At this date the trees were in full leaf, and the bugs, while abundant over the trees, did not appear to injure the full-grown leaves. They did, however, destroy new shoots on the trunk and about the base of the trees.

The pecan bud-worm and twig girdler have caused some injury to pecan nurseries and groves.

An aphis (*Callipterus carvella* Fitch) was found in abundance in a pecan grove near Valdosta, in south Georgia, but did not appear to cause much injury.

MISCELLANEOUS INSECTS.

The ragweed borer (*Eucosma strenuana* Walk.) was bred from ragweed collected at Augusta, August 22. Nearly every ragweed plant examined was found to have from one to several borers. The larvæ are easily located by the swollen spaces on the stems.

Sibine stimulea Clem., the saddle-back caterpillar, was found on rose at Middleton, and on pear nursery stock at Whitesburg, both during September. One larva collected on September 21 was barely half-grown.

Megalopyge opercularis S. and A. was frequently sent to the office last summer. Several correspondents reported great discomfort from being poisoned by touching the larvæ. This insect must have been much more common than usual to create so much attention.

The bee moth (*Galleria mellonella* L.) was bred from bee comb taken from hives at Cornelia and near Atlanta. While no study has been made to determine the distribution of this pest in Georgia, we feel sure that it is not uncommon.

No attempt has been made by the writer to mention all the insects that have come to our attention during the year. Many are too common to deserve mention. On the whole, the insects have appeared in greater variety, if not in greater numbers, than in recent years.

In reply to an inquiry, Mr. Smith (Georgia) stated that he had used 15 per cent kerosene emulsion for the woolly aphis and had secured good results. Thirty per cent had not injured the trees, while 40 per cent had caused some injury.

A paper was read, entitled:

OBSERVATIONS ON INSECT ENEMIES OF TOBACCO IN FLORIDA IN 1905.

By W. A. Hooker, *Washington, D. C.*

While engaged, during April, May, and June, 1905, at Quincy, Fla., in studying the tobacco thrips (*Euthrips nicotianæ* Hinds)[a] and methods for its control, the writer had opportunity to observe other insects affecting the tobacco crop and takes this occasion to present briefly the notes made.

THE BUDWORMS.

(*Heliothis obsoleta* Fab. and *Chloridea virescens* Fab.)

Aside from the tobacco thrips the budworms are the most destructive pests with which the Florida tobacco planter has to deal. The former species, the bollworm of cotton, is undoubtedly the more abundant, its moths having been observed in the tobacco field more commonly than those of the last named. On April 16 eggs were observed on the lower surface of young tobacco plants in the seed bed. As the plants get larger and after they are transplanted the eggs seem to be laid largely in the tender folded center leaves upon which the worms feed as they emerge. If upon hatching they are allowed to feed for a single day, much injury is done, a small hole in the leaf bud at this stage developing later into numerous large holes in the mature leaf or leaves. As described and recommended by Prof. A. L. Quaintance,[a] and by Dr. L. O. Howard,[b] it is the practice to sift into the leaf bud Paris green, in corn meal as a diluent (1 tablespoonful of Paris green to 1 peck of sifted corn meal), by the use of perforated tomato cans or baking powder boxes, attached to handles. The leaf buds must be kept constantly covered with this mixture, two applications per week ordinarily being sufficient, but three being occasionally necessary. When the mixture is applied at a greater strength the buds are burnt and seriously injured. After the plants reach the height of 2 feet it is necessary to open with one hand and with the other to place a pinch of the mixture in the bud. While corn meal is largely used as a diluent it is also a common practice to add lime (air-slaked) and sand, 2 quarts of each to 4 of corn meal. The lime, however, seems to be objectionable in that it possesses the property of adhering to the tobacco after it is harvested. Again, road dust is occasionally used as a diluent. Corn meal, however, is now used by the majority of the tobacco planters. The worms seem to eat the meal and with it the Paris green.

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[a] The remedial treatment of the tobacco thrips has been considered in Circular No. 68, and a detailed account of the insect is published in Bulletin No. 65 of the Bureau of Entomology, U. S. Dept. of Agriculture.

The annual cost in treating the budworm, for labor and supplies, has been estimated by several planters as ranging from $12 to $15 per acre.

When the plants are permitted to bud, for seed, the worms are very destructive, as they bore into the green buds and seed pods and destroy a very large percentage. Applications of Paris green assist to some extent in preventing this injury.

Cultural methods in connection with this pest do not seem to have been recommended, nor are they practiced by the tobacco planters. As recommended for cotton, corn may be found of sufficient value as a trap crop, when planted around tobacco fields, to warrant its use in this manner. When clean culture between crops is followed, as recommended in connection with the tobacco thrips, the budworm will be in part destroyed in the pupal stage by the plowing of the fields.

As the pods of the cowpeas are the favorite food of budworms, when grown in the field between crops (as sometimes practiced), they should be plowed under or harvested and the field plowed late in the fall. In this way many of the pupæ will be destroyed, for it is in this stage that the winter is passed, from 2 to 7 inches below the surface of the ground.

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[a] Bulletin No. 48, Fla. Agrl. Exp. Sta., pp. 184–187 (1898).

[b] Yearbook U. S. Dept. of Agric. for 1898, pp. 132–134, and Farmers' Bulletin 120, pp. 14–15 (1900).

As the early spring moths deposit from 400 to 1,200 eggs within a period of ten days, the importance of destroying the pupæ and as many of the early spring moths as possible can not be emphasized too strongly.

A four-winged fly belonging to the family Braconidæ was found quite numerous in some tobacco fields. The insect has been determined by Dr. Wm. H. Ashmead as *Toxoneuron seminigra* Cress. Doctor Ashmead states that it may be found to be parasitic on the budworm.

THE HORNWORMS OR TOBACCO WORMS.

(*Phlegethontius quinquemaculata* Haw., and *Phlegethontius sexta* Joh.)

A few eggs of the hornworms or tobacco worms were observed on the tobacco leaves, both in the seed bed and in the field, on April 20. They do but little injury before the middle of May, at which time it is the practice of many planters to commence using the powder gun with 1 pound of Paris green to 5 of lime, applications being made twice each week and continued until harvesting commences. Others practice picking in place of the powder guns, women and children going through the fields and examining the plants for worms. On one plantation visited when the moths begin to appear the superintendent offers a reward, usually 1 cent each, for the moths captured. In this way many are destroyed, being killed by the men, who find them on the plants and in the shade field on the posts when hoeing, the stimulus of the reward keeping them constantly on the lookout for the moths. This destruction of the moths before they lay is very important when we consider the large number of eggs that are deposited.

Paris green has been applied by spraying, but is now entirely replaced by dusting (1 pound of Paris green to 5 pounds of lime) with a blowgun. Aside from the effect of the Paris green (applied with a blowgun) on the hornworm, it aids in controlling the budworms, grasshoppers, flea-beetles, etc. The one disadvantage in its use lies in occasional burning when the application is followed by a light rain—one insufficient to wash off the Paris green before burning takes place. One field of sun tobacco was observed that had been burnt quite badly in this way. Care should be taken to avoid this, and also to see that the application is not made shortly before or closely following the spraying of emulsion for the thrips. It is a good plan to apply it as near as possible to the time of applications of Paris green and meal for the budworms. This will, of course, apply only to shade tobacco on which emulsion spray is used.

The hornworms of the second brood, which appear in July, are injurious in that they are likely to be taken into the barn on the tobacco when harvested and there consume the whole leaf and often near-by leaves. Care when priming or the previous use of an arsenical application will, however, prevent such injury.

Much is gained in preventing the moths from entering by keeping the sides of the shade field patched and the gates closed.

THE TOBACCO FLEA-BEETLE.

(*Epitrix parvula* Melsh.)

The tobacco flea-beetle is a small but important enemy of Florida tobacco. It was observed during the summer of 1905 working especially on tobacco in the immediate vicinity and bordering the seed bed, from which it spreads through the field. Applications of Paris green with a blowgun are depended upon for control, and are as satisfactory as any remedy that can be recommended.

GRASSHOPPERS.

Grasshoppers were very numerous in the shade field, and with the flea-beetles cause much injury to the shade tobacco. They are a very hard and unsatisfactory pest to combat. Aside from the general application of Paris green with the blowgun, on one plantation many were killed by hand; this was done by going along the road through the field and crushing them while on the ground by use of a slat or narrow board used as a paddle. This, to be sure, is a slow and crude method of extermination, but much injury can be prevented in this way at small expense.

It is the practice of many planters to keep a flock of guinea hens in the shade field, as they catch and devour large numbers of the grasshoppers. Others, however, feel that the benefit is offset by injury done in tearing the leaves. Clean cultivation between crops will assist by causing the adults to look elsewhere for food and a place for egg deposition. Fall plowing will help in destroying the eggs.

THE SALT-MARSH CATERPILLAR.

(*Estigmene acræa* Dru.)

The salt-marsh caterpillar, commonly known at Quincy, Fla., as the "woolworm," was observed as the source of considerable injury on one plantation. In a field examined May 15 one section had been largely destroyed, only the midribs and stems remaining. From one plant the caterpillars pass to the next, injuring the young plants only. They can be controlled by hand picking or the use of arsenicals.

BEETLES WHICH INJURE NEWLY TRANSPLANTED PLANTS.

Several beetles were found to do more or less injury to the young newly transplanted tobacco plants, and the nature of their work was much the same. When the young plants are first transplanted their leaves wilt and lie upon the ground. It is at this stage that the beetles do the injury; lying upon their backs upon the ground they perforate the leaves and feed thereon. A species belonging to the Tenebrionidæ seems to be the chief offender. This has been determined as *Blapstinus metallicus* Fab. by Mr. E. A. Schwarz, who says that it is a species quite generally distributed through the South.

Two other species found similarly working, but in numbers insufficient to be of economic importance, have been determined as *Epicœrus formidolosus* Boh., of the family Otiorhynchidæ, and *Opatrinus notus* Say, another tenebrionid.

THE TOBACCO LEAF-MINER OR SPLITWORM.

(*Phthorimæa operculella* Zell.)

This insect seems to be of no economic importance whatever in Gadsden County, only four or five affected leaves being noticed while at Quincy. At Dade City, in Pasco County, it has, however, become the most important insect pest with which the tobacco planter has to deal. The writer has been informed by Mr. W. W. Cobey that during the season of 1906 an average of no less than two leaves per plant has been thus affected.

CUTWORMS AND WIREWORMS.

The cutworms (Noctuidæ) were observed as especially injurious on one plantation. They are not confined in their work to the newly transplanted plants, but even attack plants a foot high with stalks one-fourth to one-half of an inch in diameter. Neither do they confine their feeding to the portion of the plant at or below the surface, but often crawl up the stalk. A number of plants examined were found to have been cut off 2 inches above the ground. In freshly cut stalks the worm can always be found near the stalk and destroyed.

Wireworms belonging to a species of Drasterius were found very destructive in an 8-acre field of sun tobacco on which oats and cowpeas had been grown the previous season. On account of their feeding near the surface on the stems of the young plants, boring up and down in the pith, a nearly complete resetting of the field was necessary. A search in the soil about a wilted plant would reveal one and in some cases several white wireworms from one-half to 1 inch in length.

In Wisconsin, Paris green, and in Ohio, turpentine, has been used in the water when setting as a repellent for cutworms. As an experiment with the wireworms, 1 quart of kerosene emulsion to a cask of water was tried, each plant being watered. As no further injury from the worms took place it was supposed that the emulsion had the desired effect.

It seems to the writer desirable that kerosene emulsion be used in the water when transplanting as a repellent to both cutworms and wireworms.

LEAFHOPPERS OR SHARPSHOOTERS.

There are two species known as sharpshooters of cotton that were commonly observed in the tobacco field. These have been determined by Mr. Otto Heidemann as *Aulacizes irrorata* Fab. and *Oncometopia lateralis* Fab. The latter species was supposed by one planter to injure the bud, specimens being collected and handed the writer. The work of the budworm, however, must have been mistaken for that of these insects, as the sharpshooter can not be the source of an appreciable injury to the plants.

THE CIGARETTE BEETLE.

(*Lasioderma testaceum* Dufts.)

This pest seems to be present in small numbers in nearly all packing houses, occasionally causing some considerable injury to the tobacco in bulk.

REMEDIAL PRACTICES.

Cheese cloth is used to furnish shade for tobacco on a considerable acreage in place of slats. In connection with the insect problem it has an advantage over slats in that it keeps the insects out to a large extent. The slats, however, do much to keep out the hornworm moths, the worms being much more numerous on sun tobacco. It is equally important, however, whether cloth or slat shade be used, that the sides be kept patched and the gates closed, which fact does not seem to be appreciated by many planters.

Commencing while the plants are in the seed bed, kerosene emulsion and Paris green should be applied. These applications must be continued, the emulsion twice a week until plants are half grown, the Paris green in the blowgun twice a week from the first appearance of hornworms. Paris green and corn meal must necessarily be applied at least twice a week, commencing as soon as the plants are transplanted.

Mr. Britton stated that the cucumber flea-beetle had caused considerable injury to tobacco plants in Connecticut; that he had dipped the plants, roots and all, in a wash made of 1 pound of arsenate of lead to 10 gallons of water. This treatment did not injure the plants.

Mr. Fletcher stated that Bordeaux mixture seems to repel the cucumber flea-beetle; but it is claimed by hop growers in British Columbia that neither Bordeaux nor Disparene is effective for controlling *Psylliodes punctulata* Melsh., which is a most serious pest in hopyards there. He asked for suggestions as to a remedy.

Mr. Titus stated that the species of this genus work on sugar beets, and that they can be driven away during irrigation by disturbing the beets, thus causing the beetles to jump into the water and be swept away.

Mr. Hooker stated that Lindeman had described *Thrips tabaci* from Russia several years ago, and reported that it attacked tobacco in that country. This species is distributed from New England to Texas, but feeds upon onions. He asked if anyone present had observed it on tobacco.

Mr. Quaintance thought it probable that Lindeman had confused two or more species in his account of the life history of *Euthrips tabaci* Lind. It is stated by him that this species infests tobacco and deposits its eggs along the veins. With the American insect designated under this name, the eggs are deposited beneath the epidermis of the leaf, and there are other equally important points of difference in the habits and life of the species. So far as he knew, they never attacked tobacco, but infested onions (producing the so-called "silver-top"), cabbage, cauliflower, etc. He had frequently seen these insects very abundant on the above-mentioned plants in proximity to tobacco fields in Florida, but the insects did not attack the tobacco.

Mr. Hinds stated that there was considerable confusion in regard to the species of thrips.

Mr. Washburn mentioned finding the cigarette beetle in boxes of fine-cut tobacco.

The following paper was presented:

OBSERVATIONS ON CECIDOMYIIDÆ.

By E. P. Felt, *Albany, N. Y.*

[Withdrawn for publication elsewhere.]

A paper was presented entitled:

A SPRAY NOZZLE FOR THE MECHANICAL MIXTURE OF OIL WITH WATER OR OTHER LIQUIDS.

By E. Dwight Sanderson, *Durham, N. H.*

During the year 1900 the writer made a series of tests of the oil and water mixing pumps at the Delaware Experiment Station. Practically all of such pumps on the market were thoroughly tested, using various nozzles, single and double hose, simple and double pipe extension rods, etc. Altogether many hundred individual tests were made, and the total result of the work tended to show that none of the pumps could be relied upon to give uniformly the percentage of oil desired. A detailed discussion of the mechanical faults of these pumps is not necessary at this time, but it may be stated that those pumps made with but a single pump drawing from the barrel and oil tank at once were found entirely unreliable, whereas those having two pumps, one in the oil and one in the water tank, and the percentage of oil regulated by the length of the stroke of the pumps, were found much more reliable, although in many cases they failed to deliver the proper percentages at the pump before the liquids mixed. In none of this type, even with the double-extension rod having an inner tube conveying the oil to the nozzle, was the unequal mixing of the oil and water in the hose and extension rod wholly prevented, so that variable percentages frequently occurred. The results of this work were never published, but the records exist in support of the above summary.

It soon became apparent that to eliminate the mixing of the oil and water in the hose and pipe before reaching the nozzle, some form of nozzle must be devised which would mix the two liquids as they left it. Such a nozzle was therefore devised and a working model was made by Queen & Co., a drawing of which was made by them as shown in fig. 6. In the Thirteenth Report of the Delaware Agricultural Experiment Station (1901, p. 196) the writer made mention of this nozzle as follows: "We have had a nozzle made according to plans originated by us which it is trusted will prove more satisfactory in making a uniform mixture of a given percentage of oil and water."

In his recent bulletin upon the San Jose scale,[a] Mr. C. L. Marlatt remarks concerning the oil and water mixture, as follows:

> The best outlook for good apparatus of this sort seems to be in carrying the oil and water in separate lines of hose to the nozzle, uniting them in the latter, and in maintaining an absolute equality of pressure on both oil and water tanks by employing compressed air as the motive force, kept up by an air pump, the air chamber communicating with both of the liquid receptacles. * * * One or more manufacturers are now working on an apparatus of this description.

This so closely describes the system originated by the writer in 1901 that it seemed wise to make a record of our work along this line in the proceedings of this association, as the writer was not aware that any manufacturers had taken up the idea or indeed that it had attracted any attention, though we had described the apparatus to several entomologists in a general way.

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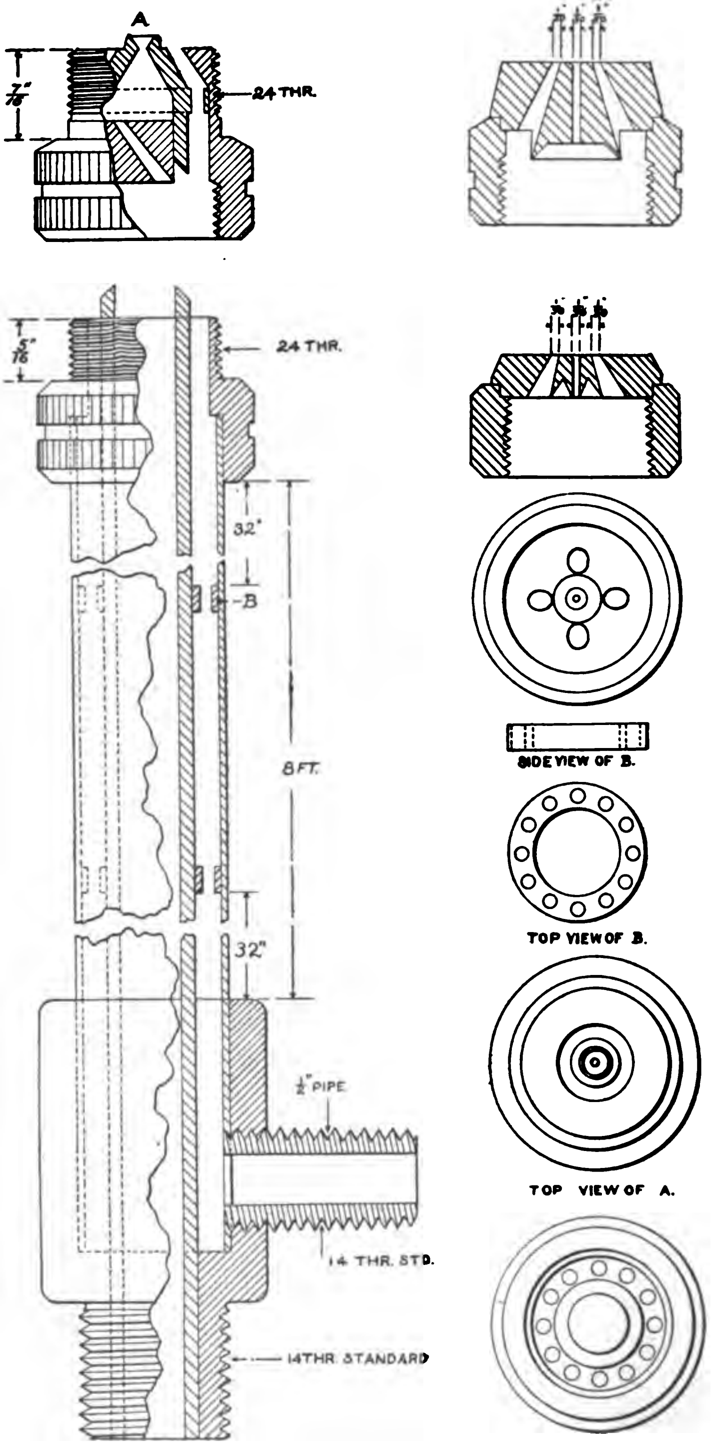
[a] Bulletin 62, Bureau of Entomology, U. S. Dept. of Agriculture, p. 77.



SIDE VIEW OF B.

TOP VIEW OF B.

TOP VIEW OF A.

BOTTOM VIEW OF A.

Fig. 6.—Diagram of spray nozzle for the mechanical mixture of oil with water or other liquids.

The general structure of our apparatus has already been indicated by the quotation from Mr. Marlatt. A compressed-air pump was attached to two steel boilers, which were connected so that the same pressure was constant upon both of them. Oil was placed in one tank and water in the other, and a lead of hose carried each separately to the extension rod which kept them separate until after they had left the nozzle. The general appearance of the pump was much like that in figure 7, which is that of a compressed-air sprayer made by an Ohio manufacturer, but which was not designed for using oil and water. The extension rod and nozzle are shown in figure 6. The rod is constructed of brass, is of any desired base, and consists of an inner tube carrying the oil for the hose connecting it with the oil tank and an outer tube connected with hose to the water tank. At the end of the rod proper the base of the nozzle was screwed on, which

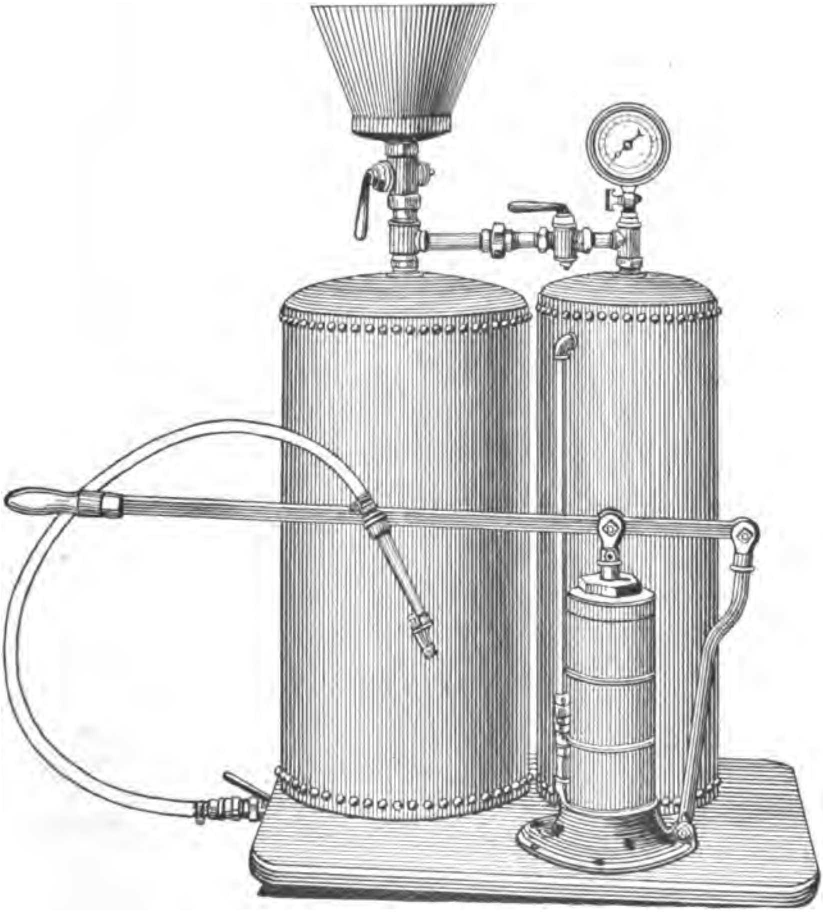


FIG. 7.—Compressed-air pump, suitable for spraying a mechanical mixture of oil and water, when fitted with the nozzle herein described.

gave the inner oil stream a tangential motion, thus forming a cone-shaped spray, upon leaving the aperature, like that from a Vermorel nozzle. Testing the nozzle convinced us that this section was not necessary, and that it might be eliminated and the nozzle cap put directly upon the ends of the two pipes. The end of the inner oil pipe fits into grooves of the nozzle cap so that no connection between the oil and water is possible except after they have left the nozzle. The oil leaves the cap through a central, round, reamed hole, 0.02 inch in diameter. Around this central orifice are two or more holes, each pair being directly opposite each other and opening into the outer water pipe. The holes for the water are reamed so that the streams from them are directed to meet in front of the center of the nozzle the same as in a calla nozzle. Here they come into contact with the straight or cone-shaped oil jet and the whole breaks into a fine spray evenly composed of oil and water. It is evident that if the streams leave the nozzle under the same pressure and the apertures be of the same diameter, the spray must then consist of 33⅓ per cent oil, if there be two water jets and one oil jet; 20 per cent oil, if there be four water jets, etc. The percentage of oil may, therefore, be readily regulated by having various nozzle caps with a different number of water holes or with water holes of various sizes which have been tested to give a greater percentage.

Several such caps were made and the whole apparatus was given a thorough test by us. Various minor troubles were found in its structure which it would require some little time and experiment to eliminate, but our tests showed that the apparatus did practically what it was designed to do, and that with proper mechanical execution, the principles upon which it was based were undoubtedly correct. While its perfection was under way, the writer was called to Texas, where circumstances did not permit the completion of the work, and the Delaware station has given it no further attention since that time.

It is the writer's belief that a nozzle may be perfected along this line, for there is nothing specially new in the structure of the pump; and that we might thus have a perfect mixture of oil and water or other mixture, which, if it could be secured, would be of the greatest service against many insects. This now seems to the writer more of a problem for the pump manufacturer than the entomologist, and our work toward the solution of the problem is therefore made public at this time.

A brief discussion of mechanical mixing pumps followed.

Mr. J. B. Smith stated that good work had been done by some of these pumps in certain sections in New Jersey. The general opinion seemed to be that pumps of this character now on the market would not mix the oil and water accurately.

A paper was read, as follows:

THE BEET LEAF-HOPPER.

By E. D. BALL, *Logan, Utah.*

[Withdrawn for publication elsewhere.]

The following title was presented, and the paper will be published in the report of the Bureau of Science of the Philippines:

PROBLEMS IN ECONOMIC ENTOMOLOGY IN THE PHILIPPINES.

By C. S. BANKS, *Manila, Philippine Islands.*

The following papers were read by title and ordered printed in the "Proceedings:"

OCCURRENCE OF THE THROAT BOT IN CUBA.

(*Gastrophilus nasalis* L.)

By C. F. BAKER, *Santiago de las Vegas, Cuba.*

Although the horse bot (*Gastrophilus equi* Fab.) is commonly known in Cuba, I can not find that *nasalis* has yet been reported. I had had specimens of the latter from Texas, Kansas, and Wyoming. Now, it has been taken flying about the plow mules here on the grounds of the Estacion Agronomica.

This occurrence is especialy interesting, because with it may be noted an apparent divergence in habit. Ordinarily it is said to annoy animals by striking for the vicinity of the neck for the deposition of its eggs. Here, as we have observed it, it flies almost entirely beneath the body. Whether this shows any definite indication of a difference in the egg-laying habit remains to be determined.

REMARKABLE HABITS OF AN IMPORTANT PREDACEOUS FLY.

(*Ceratopogon eriophorus* Will.)

By C. F. BAKER, *Santiago de las Vegas, Cuba.*

A common Cuban fruit which occurs in gardens and patios is the tree gooseberry, or grosella, a species of Phyllanthus. This tree is commonly completely and rapidly defoliated by a most pernicious pest—the larva of *Melanchroia geometroides* Walk. I had observed this insect in passing as to its parasites, none of which appeared to exercise the least check upon it. One day, in visiting a tree swarming with the larvæ and almost defoliated, I discovered that great numbers of them were dead and dying, their blackened skins hanging from the twigs or lying on the ground beneath. Drawing nearer, I found that the larvæ were being attacked by a very small sucking fly, from one to half a dozen being perched on each larva, on which they remained until it was sucked dry. Mr. Coquillett has kindly determined this fly as *Ceratopogon eriophorus* Will., previously reported only from the island of St. Vincent. This mosquito-like method of attack and its remarkable effectiveness were very novel and interesting to me.

SOME NOTES ON LEPROSY IN HAVANA.

By C. F. Baker, *Santiago de las Vegas, Cuba.*

In doing what I could to investigate the possible relation of fleas to leprosy, I have examined the leper hospital of San Lazaro, in Havana; and in this connection have made some observations and had some experiences which possess some psychological as well as entomological interest.

In the first place, to the hospital physicians it seemed absurd that I should busy myself with a study of the fleas of rats; absolutely nothing was said in any of their books about any possible relation of rats to leprosy. Then my attention was called to the fact that they and the nurses had been there some time and had not yet acquired leprosy though they were commonly flea-bitten; so the possibilities of infection by this means could be set aside at the outset. My suggestion that the same result might be true also of tuberculosis did not seem to carry much point. However, my business was with the rats and the lepers, and I found them far more productive of facts. The old hospital swarms with rats, and the rats have fleas unlike rat fleas of the temperate regions, and which, as I have noted in Science, are very nearly related to *Pulex irritans*. Talking with the lepers brought to light immediately some remarkably significant points. They were greatly interested when a possible relation between the rats and their terrible disease was hinted at, and immediately united in saying that the rats frequently carried sores like theirs and were frequently minus ears or tail. On the cots there were no nets, nor were there screens on the windows. I had the general evidence of the lepers themselves that it was no uncommon thing for rats to climb on to the cots at night and gnaw at their insensible sores. Naturally my interest in all this rose by leaps and bounds, and I immediately set traps for the rats. The first one caught had a sore on its body, and I hurried with it to the president of the board of control of the hospital, who is also the director of the city bacteriological laboratory. Together we went at once to the laboratory and asked the bacteriologist to prepare and stain some cover glass smears from the sores, applying the ordinary tuberculosis test, which is good also for leprosy. However, this man refused to have anything to do with the matter.

My contention was not that the rats had leprosy, nor that the fleas could carry it—though, as I have stated elsewhere, I should dislike to have a flea bite a leprous blotch and then turn its attention to me—but that the whole matter was one crying urgently for investigation and that the hospital in its present condition, within the city and open to visitors and rats and mosquitoes and flies, was a possible menace to the whole community. I told the authorities that they might easily undertake a piece of investigation there that would attract the attention of the whole scientific world and contribute much to scientific knowledge of these matters. But my efforts were sterile so far as exciting any further efforts toward investigation was concerned. Yet not wholly without results either, since somewhat later the junta of the patrones of this hospital, without further facts than those I had brought out, passed a resolution in which they state it as their belief that it is possible that leprosy may be communicated by flea bites. The matter was brought to the attention of the president, and he took steps toward the removal of the hospital. The matter was again laid before the Provisional Governor after his arrival, and it seems now as if the hospital might really be removed from the city at an early date.

If any insects are really concerned in the transmission of leprosy or bubonic plague, I consider that they are more likely to be fleas than either mosquitoes or flies, since the affected areas are usually kept covered. The great length of the usual period of incubation of leprosy and the lengthened course of the disease make direct observation and evidence very difficult in any case. In the meantime I believe that it would be by far the wisest course to rigidly exclude from leper hospitals like the San Lazaro in Havana all rats, cats, dogs, fleas, mosquitoes, and flies. This would not be a difficult matter to accomplish.

ON THE ERADICATION OF THE BLACK-CURRANT GALL-MITE.

(*Eriophyes ribis* Nalepa.)

By Walter E. Collinge, M. Sc., F. E. S., *Birmingham, England.*

For upward of thirty-five years black-currant growers in the United Kingdom have waged war against a small mite of the genus Eriophyes, but with little or no avail.

Its rapid increase toward the close of the past century, which threatened the successful cultivation of black currants in this country, led me in 1899 to institute a careful investigation into the life history and preventive and remedial measures, which investigation has been continued up to the present time with excellent results.[a]

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[a] Repts. on Inj. Insects for 1904 and for 1905.

Very briefly, the results which have accrued from this investigation are as follows:

(1) The life history has been repeatedly worked through and valuable data obtained as to the dates of egg laying, the first appearance of the mites, when the old infested buds dry up, when migration commences and ceases, when the mites were found in the new buds, and the eggs, the dates the mites were last seen, and the dates the new buds commenced to swell. These details have been recorded for eight consecutive years.

(2) Two points of considerable interest have, I think, received a satisfactory solution, viz, first, what becomes of the mites which fall off the trees? And, second, do the females continue to lay eggs throughout the year?

Hoping to obtain some solution of the first problem, I devised, early in May, 1903, a wooden frame in two halves, lined with black paper, which fit closely round the stem of a currant tree. From the end of May to the end of June thousands of mites were to be found on the tray. Many were dead, but the majority alive, and although a very careful watch was kept, none was ever found to return to the tree, but in some manner or other, possibly by attaching themselves to insects, they gradually disappeared from the tray. The percentage of dead mites was about 40 per cent.

A similar tray, filled with a fine layer of soil, gave similar results, only here the mites were much more difficult to trace. As a result of the above experiments, I conclude that of the mites which fall to the ground during the migration season many are distributed by insects, birds, leaves, etc., to other trees, the remainder dying.

About the middle of June eggs and mites in various stages of development are to be found in the center of the new buds. During the winter of 1902-3 one or more buds were examined once a week from September to March, and in nearly all cases eggs were found to be present. They were certainly very few in number from December, 1902, to March, 1903, and it seemed to me that many of them were dead. From October 14, 1903, to January 30, 1904, buds were taken from another tree and examined once a week, but in spite of the most careful searching no eggs were discovered after October.

The previous experiments [a] on the destruction of this pest, although very successful, were not of the nature that a fruit grower could apply at a cost which would repay him for the extra labor involved, although certain growers have given the spray fluid mentioned in my earlier report a trial with very satisfactory results.

The two main objections to the soap and sulphur spray fluid were, firstly, the large number of applications which were given in my experiments, and, secondly, the large quantity of soap used. But once having proved that the mite could be destroyed by the use of sulphur, it remained to be demonstrated in what form it was best applied and whether or not it could be shown that any benefit resulted from a smaller number of applications.

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[a] Report on Economic Zoology, No. 1, 1904.

With these two objects in view a series of experiments was commenced early in 1905 on a piece of land set apart and prepared for the purpose by the council of the University of Birmingham.

On this plat seven rows of bushes were planted, consisting of Black Naples, Baldwins, and Boskoop Giant. All were as badly affected with "big bud" as any that could be obtained; indeed, I have never seen worse. The plat of land was far from an ideal one and the last that a fruit grower would have chosen, so that the bushes had no natural advantages in their favor.

The experiments carried out were as follows: Rows 1, 2, and 3 were dusted with equal parts of unslaked lime and flowers of sulphur. Rows 4, 5, and 6 were sprayed with a mixture consisting of 1 pound of lime, 1 pound of sulphur, and 20 gallons of water, while row 7 was sprayed with a mixture consisting of 1 pound of sulphur, 1 pound of soft soap, and 20 gallons of water.

Summary.—It is very evident that all the bushes benefited by the application of lime and sulphur. It would have been better, however, had a little less lime been used (1 part of lime to 2 parts of sulphur has acted as well). In the case of those bushes that received a single dusting, the big buds were considerably reduced in number, not more than one-fourth of the number being present in October as there were in February. Where two dustings were given, a distinctly marked diminution over those receiving one dusting was shown, while where three dustings were applied the mite was almost exterminated. It must be borne in mind that neither a spray fluid nor dry application will reach the eggs in the buds, and it seems clear that the number of adult mites which successfully migrated from the old buds into the new ones was very small indeed. In all cases, the mites found were immature specimens.

Spraying with lime and sulphur.—The results obtained by spraying were not so good as those by dusting. A large number of buds were affected, and in many of them there were adult and immature mites and eggs. The differences between the one, two, and three applications of the spray fluid were quite in keeping with those found to obtain where dusting had been done. The fewer the applications the more buds affected and the greater the number of mites.

Spraying with soft soap and sulphur.—Row 7 was sprayed twice with the spray fluid above mentioned. When the bushes were examined in October a fairly large number of big buds was noticed;

there were, however, not nearly so many as in the previous February; roughly estimated, I should think about one-third the number. In many of these buds 12 to 20 adult mites were present, many immature specimens, and a few eggs. The result of an examination of 86 suspected buds gave an average of 4 adults, 9 immature mites, and 3 eggs per bud.

SUMMARY AND CONCLUSION.

After the experiments which have been made I feel convinced that the application of lime and sulphur will keep this mite in check, and, if the dusting and spraying is continued, will eventually entirely eradicate the pest.

Various statements have appeared in a section of the horticultural and agricultural press, stating that there is no likelihood of a cure, or even of means whereby the mite can be kept in check; and, further, that its life history is very imperfectly understood. I would warn all fruit growers against such misleading statements. The life history is now practically fully known, and the experiments which I have conducted and which have now extended over eight years have yielded results, checked by many large fruit growers, which clearly point to the fact that the application of lime and sulphur offers an effective remedy.

It is interesting to note in this particular that the destructive rust mite of the orange and lemon has been combated in a similar manner. In 1889, according to Mr. Marlatt,[a] large quantities of citrus trees were obtained from Florida, and a species of Eriophyes (*E. oleivorus* Ashmead) was undoubtedly introduced in the Rivera and San Diego Bay districts of California, where it did considerable harm in the orange and lemon groves. Mr. Marlatt states that "an estimate made from actual count, indicates that the mites and the eggs on a single leaf in midwinter may reach the enormous number of 75,000," indicating some billions of mites for each tree in the active breeding season. He further states that it "is readily destroyed by various insecticides. The eggs, however, are much more difficult to kill, and practically no wash can be relied upon to reach and destroy all the eggs of this mite. * * * The sovereign remedy for the rust mite is sulphur. * * * The advantage of the sulphur treatment arises from the fact that the sulphur adheres to the leaves and the young mites are killed as soon as they come in contact with it."

A further example of treating another species of the same genus of mites is offered in the case of the cotton-leaf blister mite (*E. gossypii* Banks.), which made its appearance in the West Indian cotton fields in 1903[b] and spread quickly throughout the islands. Here the lime-

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[a] U. S. Dept. Agric., Farmers' Bul. No. 172, 1903, pp. 38–41.

[b] West Indian Bul., 1903, Vol. IV. pp. 282 and 336.

and-sulphur treatment has proved most effective. Other species of Eriophyes have been treated with lime and sulphur, viz, *E. avellæna* Nal., *E. rudis* Canest., and *E. taxi* Murray, with equally satisfactory results.

DESTRUCTION OF MOSQUITOES IN DWELLINGS BY THE POWDERS OF CHRYSANTHEMUM, SPREAD THEREIN BY MEANS OF HAND BELLOWS OR A TOWEL.

By A. L. HERRERA, *Mexico City, Mexico.*

Ever since 1903 this commission has been commending the destruction of mosquitoes in dwellings by means of the chrysanthemum powders, spread or thrown around therein with hand bellows or a towel.[a]

ESSENTIAL RECOMMENDATIONS.

(1) In each room or apartment there should be spread daily, half an hour or an hour before bedtime, the genuine chrysanthemum powders, by means of some hand bellows, cloth, or towel.

(2) The powders should be spread uniformly in the whole room, and to that effect they should be scattered with the bellows as high as possible, in various directions, care being taken besides that they penetrate under the beds and other pieces of furniture, behind the doors, etc. In case a towel is used, it should be shaken around in a very lively manner and for some time. Some people are wont to place the powders upon a table or a piece of pasteboard and blow said powders upwardly, and at once shake a bed sheet or a towel in the center of the room.

(3) It is convenient to employ a large spoonful of powder for every room of 20 to 30 cubic meters, and a larger quantity for larger apartments.

In order to find out whether the quantity of powder that has been used is sufficient, it will suffice to spread some bed sheets upon the floor, so that the mosquitoes may fall upon them. Some of the insects should then be kept under a glass to see, on the next day, if they are really dead. Should it not be so, or should no mosquito fall upon the sheets, after an hour, even though they should be in great numbers in the room, the quantity of powder scattered should be increased or a new lot should be bought in another drug store. The same should be done when the insects have only fallen into lethargy at the beginning of the night, and again become troublesome in the morning.

(4) To avoid inflammation of the throat the person who has to scatter the powder should cover the mouth and a part of the face with a handkerchief and leave the room as soon as possible.

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[a] Boletin de la Comisión de Parasitología Agricola, Tomo II, pag. 139.

(5) The insecticide powder should be spread in the room before bedtime, it being possible for the people to enter the room after said powder has settled down.

(6) There are some kinds of the powders which are entirely inefficient; this is true of most of the powders sold by retailers in small quantities, in envelopes or in boxes, at 5 cents or less. To obtain good ones they should be bought at some reliable drug store and tried in the way above explained.

(7) In order to avoid a daily expense for powder, it is advisable to close the doors and windows early, so that the mosquitoes will not enter the apartments, and it will even be very useful to put a fine wire screen upon the windows. Should any mosquitoes, however, succeed in entering the rooms, they will be killed by the powder of chrysanthemum, an operation to be performed only when the insects happen accidentally to enter on account of the openings having been shut too late or because of any other circumstance.

(8) An excess of powder is quite unnecessary, and might even result in injury to the inhabitants.

NOTE.—It has been said that the fine powder, in large quantities, may become ignited when there is a candle in the room, but it has never been proved that such is the case when only genuine chrysanthemum powders are used. In a fumigating room made of canvas, with a capacity of 68 cubic decimeters, we blew a large quantity of genuine chrysanthemum powder, a part of which fell upon the flame of an alcohol lamp situated in the back of the room. The only powder that burned was that which touched the flame directly, whereby was produced a kind of rain of small sparks; but the fire was never communicated to the remainder of the powder, and no explosion occurred. This experiment may be made on a small scale with a candle, and thus the above statement will be confirmed, while at the same time it will be found out whether the powder contains any foreign matter which is inflammable and dangerous. Where electric light is used such a precaution is unnecessary.

This manner of destroying mosquitoes has already been put into practice. To that effect the commission of parasitology has distributed gratuitously several barrels of chrysanthemum powders under the form of small samples. The consumption of powders has been tripled, while the sale of the tablets, which only throw the insects into a state of lethargy but are very objectionable owing to their pungent fumes, was decreased.

The species of mosquito which is most frequently found in the City of Mexico and which invades the houses is *Culex pipiens* L.

NOTES ON INSECTS IN CENTRAL ALBERTA.

By P. B. Gregson, *Blackfalds, Alberta, Canada.*

With so large and ever increasing immigration from the United States, a few notes from the grain section of central Alberta may not be without interest. The early season of 1906 in this district was notable for the phenomenal outbreak of "cutworms," chiefly *Noctua clandestina* Harr., *Chorizagrotis auxiliaris* Grt., and *Paragrotis ochrogaster* Guen.—extraordinary because climatic conditions had not seemed to warrant such an outbreak.

The preceding year (1905) was normal; the fall dry, the November mean minimum temperature being 20.15° F., snow 5.85 inches; and December mean minimum 8.30° F., snow 0.75 inch. The mean minimum temperature for January, 1906, was —0.70° F., and snow 4.40 inches. Hot suns on February 1, 2, and 3 dispelled nearly all of what little snow there was, and from the middle of February to the end of March was characterized by cold snowless weather, touching — 19° F. on March 12, with all fields bare of snow, and being in fact the dryest season for ten years The total moisture from November, 1905, to May 16, 1906 (from snow and rain combined), did not exceed two-thirds of an inch. Ninety per cent of the local winter wheat was killed off. The total precipitation for the month of April and till May 16 was only 0.115 or 0.1 of an inch of moisture, a very warm and dry period, the mean maximum shade temperature for April being 60.68° F. and for May (up to the 18th) 66.10° F—a temperature above the average for ten years.

Studying these weather conditions—the reverse of a cold, wet spring—it would seem that parasites would at least have an equal chance with cutworms for surviving. But what was the result? The outbreak of cutworms was without precedent, and of parasites few could be discovered.

Every kind of vegetation seemed to be attacked by the cutworms. Among the instances of which the writer made special observation a few may be mentioned as showing the catholic nature of their food. A nursery gardener had planted in the fall of 1905 (in a brome-grass field which had been plowed up in the previous spring) an orchard of several hundred gooseberry, currant (red, white, and black), raspberry, and blackberry bushes and some hundreds of strawberry and rhubarb plants. In the spring of 1906 the young shoots of the raspberry and blackberry bushes were persistently cut through just below the soil and every bush died. The runners of the gooseberry and currant bushes shared the same fate, even the leaves being cleared off. Not one strawberry survived the attack, and the rhubarb also suffered severely. Circular pits had been dug round each bush in the fall, but did not operate as any check to the pest. Several farmers lost their entire crops of potatoes, the caterpillars killing off each shoot from the tuber. Of grain farmers, many lost from 40 to 80 per cent of oats and spring wheat; one crop visited by the writer was sown with wheat a second time and again entirely destroyed. (It was sown a third time, but too late to harvest, though it escaped the cutworms.) And so with horticulturists: Peonies, columbines, pansies, foxgloves (Digitalis), wall flowers, candytuft, campanulæ—all were attacked indiscriminately by *Chorizagrotis auxiliaris* and *Noctua clandestina*, even two young Charles XII lilac bushes being killed by having their young buds devoured (this by *Peridroma occulta* L.) Carrots, parsnips, onions, cabbages, and other Cruciferæ grown in gardens were in many cases "cleaned out" by *Noctua clandestina.*

The magnitude of the attack seemed to discourage the farmers. Remedies were tried without much success, except in gardens where close attention could be given. Where tried in gardens poisoned bran succeeded very well, but farmers seem not to have the time or the pains for applying the poison-bran remedy to their large grain fields.

As a wholesale and very fairly efficient remedy for grain fields the writer recommended heavy rolling late in the evening. This was tried by one farmer whose field was infested, the rolling being done from 10.30 p. m. till about midnight, being repeated a time or two during the young growth of grain, and resulted not only in the virtual salvation of his crop, but in a strong stand of straw (with the summer the driest on record).

In short, the farmer should, in the opinion of the writer, consistently practice the following method with his grain:

(1) Late fall plowing (plowing can often be done in Alberta till the early days of November).

(2) Drilling the grain (in spring), not sowing broadcast. Drilling facilitates the operation of the harrow and seeds deeper than broadcast sowing.

(3) Roll in evening (10.30 p. m.) when grain is appearing and soil dry.

(4) Harrow when grain is a little more advanced.

(5) Roll once more in evening (on dry soil).

(6) Harrow finally (with grain about 4 inches high).

The writer has known crops to be harrowed three times after the first appearance of grain, with most beneficial results, and, except in years of unusual prevalence of cutworms, the second rolling might be dispensed with.

It was moved and carried that the Chair appoint a committee of five to take up the work outlined in the report of the committee on testing proprietary insecticides.

The following were appointed: Messrs. E. P. Felt, C. P. Gillette, E. D. Sanderson, R. I. Smith, and H. E. Summers.

A motion was made and carried that the next annual meeting of the association be held at the same time and place as the meeting of the American Association for the Advancement of Science, the exact dates to be fixed by the officers.

The report of the committee on nominations was presented, and is as follows:

REPORT OF COMMITTEE ON NOMINATIONS.

The nominating committee respectfully submit the following list for officers of the association for the ensuing year:

For president, H. A. Morgan, Knoxville, Tenn.
For first vice-president, H. E. Summers, Ames, Iowa.
For second vice-president, W. D. Hunter, Washington, D. C.
For secretary-treasurer, A. F. Burgess, Columbus, Ohio.
For member of joint committee on legislation, Wilmon Newell, Baton Rouge, La.
For member of standing committee on nomenclature, E. S. G. Titus, Washington, D. C.
For members of council, James Fletcher, Ottawa, Canada, and S. A. Forbes, Urbana, Ill.

Respectfully submitted.

C. L. Marlatt.
H. Osborn.
F. M. Webster.

On motion, the secretary was instructed to cast a ballot of the association for those mentioned, and they were declared elected.

The committee on membership submitted the following report:

REPORT OF COMMITTEE ON MEMBERSHIP.

The committee report that it has followed the plan of the last committee on membership, which was adopted by the association. We desire to reiterate the plan proposed and adopted at the last meeting, namely:

"That the association exercise greater care as to the qualifications of candidates for election to membership, and that a considerably more conservative policy than has prevailed should be adopted. In general, only those who are already associate members should be elected to active membership; and this should occur only after they have published a considerable amount of original matter on economic entomology, based on their own independent investigations. The privilege of associate members, however, may well be extended as a means of encouragement to young men who are expecting to pursue economic entomology as a profession, but who have not yet had time to show their capability by publication or otherwise."

In accordance with these principles, the committee make the following recommendations:

(1) For foreign membership: Dr. F. Silvestri, head of entomological department, Royal School of Agriculture, Portici, Italy.

(2) For active membership: Prof. J. Troop, State entomologist, La Fayette, Ind.

(3) For transfer from associate to active membership: Dr. E. F. Phillips, Bureau of Entomology, Washington, D. C.; J. G. Sanders, Bureau of Entomology, Washington, D. C.; H. E. Burke, Bureau of Entomology, Washington, D. C.; W. A. Hooker, Bureau of Entomology, Washington, D. C.; A. F. Conradi, State entomologist, College Station, Tex.

(4) For associate members: William Beutenmuller, American Museum of Natural History, New York, N. Y.; I. J. Condit, Bureau of Entomology, Washington, D. C.; R. A. Cushman, Bureau of Entomology, Washington, D. C.; H. M. Russell, Amherst, Mass.; W. V. Tower, entomologist Porto Rico Experiment Station, Mayaguez, P. R.; H. J. Franklin, Amherst, Mass.; E. A. Back, Amherst, Mass.; E. F. Hitchings, State entomologist, Augusta, Me.; Fred E. Brooks, Morgantown, W. Va.; D. K. McMillan, Harrisburg, Pa.; H. E. Hodgkiss, Geneva, N. Y.; W. J. Schoene, Geneva, N. Y.; G. P. Weldon, College Park, Md.; Dr. T. J. Headlee, Durham, N. H.; C. N. Ainslie, Department of Agriculture, Washington, D. C.; John A. Grossbeck, New Brunswick, N. J.; R. L. Webster, St. Anthony Park, Minn.; A. G. Ruggles, St. Anthony Park, Minn.; R. S. Woglum, Raleigh, N. C.; Dudley Moulton, Department of Agriculture, Washington, D. C.; Prof. T. D. Jarvis, Guelph, Ontario, Canada.

(5) That the following be dropped, since they have discontinued entomological work: J. H. Beattie; E. E. Bogue.

And that the resignation of Prof. J. H. Perkins be accepted.

(6) For transfer from active to associate membership: Prof. C. M. Weed, Lowell, Mass.

That a committee of three, including the president and secretary, be empowered to devise and have executed a suitable form of certificate of membership for the foreign members, and that the secretary be authorized to send the certificates to the entomologists concerned.

The committee also recommend that inasmuch as there is at present considerable confusion, owing to the various amendments to the constitution, the secretary be directed to codify the constitution and by-laws and present them to the association at the next meeting.

W. D. HUNTER.
H. E. SUMMERS.
JOHN B. SMITH.

On motion, it was accepted.

The report of the committee on resolutions was as follows:

REPORT OF COMMITTEE ON RESOLUTIONS.

Resolved, That the Association of Economic Entomologists expresses its appreciation for the courtesies extended by the president of Columbia University, the trustees of the American Museum of Natural History, and the council of the New York Academy of Science, and the successful efforts of the local committee of the A. A. A. S. for its entertainment; and

Resolved, That we express our gratitude to the entomological societies of New York, Brooklyn, and Newark for the most enjoyable reception tendered by them; and

Resolved, That the association, through its secretary, tender its thanks to the Honorable Secretary of Agriculture for the publication of its proceedings, and request that the proceedings of this meeting be published in like manner; and

Resolved, That this association places itself on record as indorsing the policy of the National Government in aiding the suppression of introduced pests of a serious nature, and asks for a continuation and increase of the Congressional appropriations to the Bureau of Entomology for such work and for the introduction of natural enemies of such pests; and

Resolved, That this association has learned with great interest, through the address of President Kirkland, of the attempt now being made in Massachusetts and other New England States to control the gipsy and brown-tail moths through systematic cooperation and liberal financial provision made for prosecuting field operations and for the introduction of parasites of these insects; and, being convinced that the successful prosecution of this work will protect the entire country from a serious menace, this effort has the unqualified indorsement of this association; and

Resolved, That this association extend its cordial greetings to the newly formed Entomological Society of America, and that the programme committee of this association be instructed to arrange its programme conjointly with the programme committee of that society.

JAMES FLETCHER.
M. V. SLINGERLAND.
E. D. SANDERSON.

At the request of the representatives of the American Nurserymen's Association, the following committee was appointed by the president to attend the annual meeting of that association at Detroit in June, 1907: Messrs. H. A. Morgan, Wilmon Newell, S. A. Forbes, A. F. Burgess, and E. D. Sanderson.

The committee on certificate of membership for foreign members was appointed, consisting of the president elect, the secretary, and Mr. W. E. Britton.

President Kirkland thanked the association for the honor of presiding at this meeting, which was the largest in its history, and, as there was no further business, the meeting was then adjourned.

A. F. BURGESS, *Secretary.*

LIST OF MEMBERS OF THE ASSOCIATION OF ECONOMIC ENTOMOLOGISTS.

ACTIVE MEMBERS.

Aldrich, J. M., Agricultural Experiment Station, Moscow, Idaho.
Alwood, William B., Charlottesville, Va.
Ashmead, William H., U. S. National Museum, Washington, D. C.
Baker, C. F., Agricultural Experiment Station, Santiago de las Vegas, Cuba.
Ball, E. D., Agricultural Experiment Station, Logan, Utah.
Banks, C. S., Manila, P. I.
Banks, Nathan, U. S. Department of Agriculture, Washington, D. C.
Bethune, C. J. S., Guelph, Ontario, Canada.
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Burgess, Albert F., U. S. Department of Agriculture, Washington, D. C.
Burke, H. E., U. S. Department of Agriculture, Washington, D. C.
Busck, August, U. S. Department of Agriculture, Washington, D. C.
Caudell, A. N., U. S. Department of Agriculture, Washington, D. C.
Chambliss, C. E., Clemson College, S. C.
Chittenden, F. H., U. S. Department of Agriculture, Washington, D. C.
Cockerell, T. D. A., University of Colorado, Boulder, Colo.
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Conradi, A. F., College Station, Tex.
Cook, A. J., Pomona College, Claremont, Cal.
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Cooley, R. A., Agricultural Experiment Station, Bozeman, Mont.
Coquillett, D. W., U. S. Department of Agriculture, Washington, D. C.
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Crawford, J. C., U. S. Department of Agriculture, Washington, D. C.
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Gregson, P. B., Blackfalds, Alberta, Northwest Territory, Canada.
Hart, C. A., Illinois State Laboratory of Natural History, Urbana, Ill.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 68.

L. O. HOWARD, Entomologist and Chief of Bureau.

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

CONTENTS AND INDEX.

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I. THE PEAR THRIPS.
By **DUDLEY MOULTON**, *Engaged in Deciduous Fruit Insect Investigations.*

II. THE SPRING CANKER-WORM.
By **A. L. QUAINTANCE**, *In Charge of Deciduous Fruit Insect Investigations.*

III. THE TRUMPET LEAF-MINER OF THE APPLE.
By **A. L. QUAINTANCE**, *In Charge of Deciduous Fruit Insect Investigations.*

IV. THE LESSER PEACH BORER.
By **A. A. GIRAULT**, *Engaged in Deciduous Fruit Insect Investigations.*

V. THE LESSER APPLE WORM.
By **A. L. QUAINTANCE**, *In Charge of Deciduous Fruit Insect Investigations.*

VI. GRAPE ROOT-WORM INVESTIGATIONS IN 1907.
By **FRED JOHNSON**, *Engaged in Deciduous Fruit Insect Investigations.*

VII. DEMONSTRATION SPRAYING FOR THE CODLING MOTH.
By **A. L. QUAINTANCE, S. W. FOSTER, FRED JOHNSON, and A. A. GIRAULT.**

VIII. THE GRAPE-LEAF SKELETONIZER.
By **P. R. JONES**, *Engaged in Deciduous Fruit Insect Investigations.*

IX. THE PEACH-TREE BARKBEETLE.
By **H. F. WILSON**, *Engaged in Deciduous Fruit Insect Investigations.*

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[a] Transferred to another branch in the Bureau.

1909

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., July 20, 1909.

Sir: I have the honor to transmit herewith, for publication as Bulletin No. 68, nine papers dealing with deciduous fruit insects and insecticides. These papers, which were issued separately during the years 1907–1909, are as follows: The Pear Thrips, by Dudley Moulton; The Spring Canker-Worm and The Trumpet Leaf-Miner of the Apple, by A. L. Quaintance; The Lesser Peach Borer, by A. A. Girault; The Lesser Apple Worm, by A. L. Quaintance; Grape Root-Worm Investigations in 1907, by Fred Johnson; Demonstration Spraying for the Codling Moth, by A. L. Quaintance, S. W. Foster, Fred Johnson, and A. A. Girault; The Grape-Leaf Skeletonizer, by P. R. Jones; The Peach-Tree Barkbeetle, by H. F. Wilson.

Respectfully,

L. O. Howard,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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[a] The nine papers constituting this bulletin were issued in separate form on June 10, July 6, October 15, and October 17, 1907; January 8, April 24, and April 29, 1908; and January 20 and February 11, 1909, respectively.

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ERRATA.

Page 29, line 4 from bottom, for *Clasterocerus* read *Closterocerus*.
Page 29, line 3 from bottom, for *Zagromosoma* read *Zagrammosoma*.
Page 45, line 24, for *Mesosternus* read *Mesostenus*.
Pages 77 to 90, wherever it occurs, for *Harrisana* read *Harrisina*.
Page 87, line 12 from bottom, for inchneumon read ichneumon.
Page 89, line 14 from bottom, for *Harrisana* read *Harrisonia*.
Page 92, line 3 from bottom, for *Phlaotribus* read *Phlœotribus*.

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L. O. HOWARD, Entomologist and Chief of Bureau.

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE PEAR THRIPS.

BY

DUDLEY MOULTON,
Engaged in Deciduous Fruit Insect Investigations.

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PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE PEAR THRIPS.

(*Euthrips pyri* Daniel.)

By Dudley Moulton.

Engaged in Deciduous Fruit Insect Investigations.

INTRODUCTION.

This paper brings together the results of an investigation of the life history, habits, natural enemies, and methods of control of the pear thrips (*Euthrips pyri* Daniel), a pest of deciduous fruit trees in the San Francisco Bay region of California. The investigation was undertaken at the request of the Santa Clara County board of supervisors, who furnished the funds and liberally granted necessary facilities for a thorough and scientific study, and was carried out in the Santa Clara Valley, where the thrips seemed to be at its worst. The investigation extended through a period of fifteen months, from February, 1904, to April, 1905.[a]

The writer offers this paper rather as an introduction for future work than as a completed account, and it is intended especially for the fruit grower, that he may understand the nature of the insect and its injury. The alarm felt for the safety of the deciduous fruit industry, which the pear thrips caused during 1904 and 1905, in the light of our present knowledge need not again be experienced, and, although no effective means of control are yet offered, a knowledge of the life habits should do much to clear away the uncertainty usually following the first appearance of a destructive pest in any locality.

OCCURRENCE AND DISTRIBUTION.

The pear thrips is known to exist in the San Francisco Bay counties and along the Sierra Nevada foothills, but it is not known how widely the pest is distributed outside of these localities. It is still a question whether the insect is a native of California or an introduced form. The pear thrips may have had some indigenous plant, such as the wild plum or cherry, for its original food plant, and later, as large fruit-growing districts were developed and as the insect found more and better food, it may have changed its feeding habits from the wild to the cultivated plants. This would be a not unusual change. On the other hand, it may have been imported and, finding conditions favorable here and no effective natural enemies present, may have increased and spread rapidly.

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[a] The writer wishes to acknowledge the work of Mr. Earl L. Morris and Mr. C. T. Paine. He is indebted also to Prof. W. R. Dudley, head of the department of systematic botany, and to Dr. G. H. Pierce, of the Leland Stanford Junior University, for literature and helpful suggestions in carrying on the work on the fungus which appears to be one of the natural checks for *Euthrips pyri*, and finally to Prof. Vernon L. Kellogg for his ever helpful suggestions and encouragement.

In 1904 the pest was thought to be strictly local in the Santa Clara Valley, but in 1905, when the insect had become better known, it was found to be widespread in the San Francisco Bay regions and its ravages were being felt in fruit sections in other than this one valley. A peculiar blighting of blossoms had been commonly observed in several localities in the Santa Clara Valley previous to 1904, and this blighting was invariably followed by an almost complete failure of crop. Its cause was not at first explained, for trees were injured within a very few days and the insects, as it happened, were gone before the owner was aware of the injury.

The pear thrips seems to have reached a maximum in numbers during the season of 1905. Large orchard sections, often miles in length, suffered an almost complete failure of crops and these worst infested areas were in the heart of the best fruit sections of the valley. All of this loss, however, can not be charged to the thrips, for there occurred unusually heavy and driving rains during the blossoming season of this year, and it was often impossible to determine the relative amount of injury caused by the thrips and that caused by rain, except where thrips were found feeding before the storms came on. The season of 1906 proved to be a more hopeful one. Thrips, fewer in numbers, were late to appear, and the early injury to buds was not so apparent. The trees blossomed almost in the normal way. The later injury to fruits, however, was quite as noticeable. The scab on mature prunes—the never-failing evidence that thrips have been feeding in the spring—depreciated the value of the fruit in all of the thrips-infested regions.

NATURE AND EXTENT OF INJURY.

Injury to plants is the direct result of the feeding and ovipositing of the thrips.

DESCRIPTION OF THE MOUTH PARTS.

The mouth parts of thrips project from the lower posterior side of the head and have the appearance of an inverted cone (fig. 1). The mouth opening is in the small distal end, and through it the stylets or piercing organs are projected when the insect is feeding. The rim at the tip is armed with several strong, chitinous points, which figure prominently in tearing open the plant tissues. The insect first pierces the plant epidermis with the stylets, then, moving the cone tip backward and forward, it enlarges the opening and lacerates the plant tissue by means of the barbed snout. It then pushes the tip of the mouth cone into the puncture thus made and sucks in the plant juices. Larvæ feed in a similar way, having similarly constructed mouth-parts.

RELATION OF THE BUDDING AND BLOSSOMING OF TREES TO THE FEEDING HABITS OF THRIPS.

The dark-brown adult thrips arrive on the trees in late February and early March, the period of early opening buds and first blossoms; they are common in March and April, the two months of bloom and early leaf, and all are gone from the trees by the middle of May. Only a few adults can be found after the 1st of May, and most larvæ have reached full growth by this time and have gone into the ground. Thus it is that the active feeding stages of the thrips coincide with the budding, blooming, and early leaf periods of the host trees.

The difference in bud formation and progress of development of various deciduous trees influence to a large extent the manner of injury which thrips inflict. Trees may be divided for the sake of convenience, in regard to the bud structure, into two groups, namely: (1) Those in which a single fruit bud produces one blossom, such as the almond, apricot, and peach; and (2) those in which a single fruit bud opens out to form a cluster of blossoms which later produces a cluster of fruits, as the prune, cherry, pear, and apple.

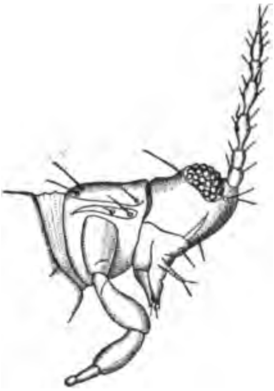


FIG. 1.—The pear thrips (*Euthrips pyri*): head and prothorax from side, to show mouth-parts. Much enlarged (original).

The relative blooming periods of the several varieties of fruit on which thrips inflict injury, as found in the Santa Clara Valley, may be noted as follows:

Group 1: Almonds, late in February; apricots and peaches, early in March.
Group 2: Prunes, middle and last of March; cherries and pears, early in April.

These periods vary from year to year and the varieties of each fruit also vary to a large degree, but the general order of blooming is suggestive. Opening buds precede full bloom by eight or ten days.

The almond, of the first group, presents an interesting study of the feeding habits of thrips. The bud development occurs during early February, early blossoms from February 5 to 16, and full bloom from February 9 to 20 and later. Thrips appear about February 25 or March 1, and it is evident that almond blossoms are well along before enough thrips have appeared to become especially injurious. Many instances can be cited where thrips were especially numerous on almond trees, often as many as 25 or 50 inhabiting a single blossom, and yet the trees set and matured a full crop of nuts. The insects did not have an opportunity to attack the opening buds, and after blossoms were open they preferred the nectary glands on the inside of the calyx cups. They did not, apparently, relish any other parts of these particular blossoms, and the pistil, stigma, and young fruits were not attacked. Stamens were weakened, for they arise from the rim of the calyx just above the place where the insects find their enticing food, but the pollen had already ripened and had been shed. Thrips can be found as numerously on almonds as on any other variety of affected trees, but there is a large, newly exposed leaf and blossom surface, and the greatest danger period is passed before the insects arrive. For these reasons the trees are able to support many thrips without the amount or the quality of their fruit being appreciably affected.

The peach, especially the Muir and the Nicols' cling varieties, suffers as much as other fruits, but the acreage in the Santa Clara Valley is not large as compared with that of the prune, for instance; consequently the damage has not been so marked. The period of opening buds and blossoms occurs just at a time to permit of thrips entering them from their earliest development. The swelling bud pushes apart its outer winter protecting scales and thrips immediately force a way in. The insects feed on the tender, closely plaited tips of petals, which are readily killed. They force an entrance between calyx lobes and petals, feeding as they go, and soon reach and attack the very small and fragile blossom stem. This is soon destroyed. Later, the blossoms which may have escaped the early injury are attacked from within, the thrips feeding on the inner flower parts. The piercing and rasping manner of feeding is very disastrous to tender plant tissue, and fatal injury can be effected by a very few movements of the powerful mouth cone with its armed tip. The writer has often examined peach trees which had but recently been attacked by thrips and found that almost every blossom would fall out from its cluster of scales when the limbs were gently tapped. Badly infested peach trees do not bloom at all.

Apricot blossoms are similar to those of the peach and are injured in the same way.

The thrips is at its worst on trees of the second group, which includes the pear, prune, cherry, and apple. These fruits bloom later, which permits the gathering of thrips in numbers before buds are at all advanced. The writer has found thrips on cherry and prune trees waiting, as it were, for the buds to open, and he has found as many as 75 individuals in a single blossom which opened prematurely early. A thrips enters a prune bud through the tip and forces a way down the center of the cluster, feeding as it goes on the contiguous sides of the several blossom buds. Normal growth ceases immediately. The untouched outer side of each blossom bud develops for a time, but the injured inner part becomes brown and dies. This causes each flower bud to turn in toward the center, and the whole cluster eventually falls. (See Pl. I, fig. 1.) When thus injured, most blossoms do not open at all, but if they do thrips are able to enter and feed in the more vital flower parts. Only a few blossoms survive both periods of injury when thrips are very numerous. The insects attack blossom and leaf buds alike and, in fact, every part that offers new and tender plant tissue.

Pears suffer mostly during early bud development, and blossoms are nearly all dead before the clusters open.

Cherries present a more resistant growth. There is a decidedly sticky secretion on the surface of newly exposed leaves, and often wings of thrips stick fast and many are thus trapped. Cherries develop so rapidly that when buds once start, blossom clusters are able to push out, often almost unharmed, even when many thrips are present. These clusters form ideal places for oviposition, and, as will be seen later, cherry trees which may be able to resist the early injuries of feeding will suffer from the effects of ovipositing.

Thrips have displayed very decided preferences for certain flower parts. It has been mentioned that they choose the inner side of the almond calyx cup. In prunes they are partial to the tiny blossom stems and to the tips of petals and, when blossoms have opened, to the stigma and style. This last injury is especially noticeable on cherries, where the writer has many times found the stigmas and styles blackened as a result of the feeding of thrips, while the rest of the blossoms was untouched.

Injury on leaf buds and on tender foliage is almost as marked as when blossoms alone are attacked, although there can be no closely drawn line of distinction, because of the close interrelation of leaf and blossom buds. Trees that have been ravaged for three or four days can not again put forth new leaf buds and assume a natural growth for several months, and then they appear sickly for the entire year. Often they can not start anew until the thrips have actually left the trees, as the insects continue to hinder each new effort which the trees may make.

The pear thrips is known to feed on the following plants, and it is probable that this list, extensive as it is, is not complete: Almond, apple, apricot (several varieties), cherry, fig, grape, peach (Muir and Nicols' clings preferred), pear (especially Doynne du Comice and Bartlett), plum, prune, walnut (English).

The insect shows a decided preference for certain varieties of prunes, pears, and peaches, but of the other fruits all varieties seem to be attacked alike. The pear thrips has been collected from the following indigenous plants: Blossoms of the madroña (*Arbutus menziesii*) and wild California lilac (*Ceanothus thyrsiflorus*), and foliage of poison oak (*Rhus diversiloba*). All of these plants, however, were near thrips-infested orchards, and, moreover, only a few individuals were taken from each of the plants.

FEEDING HABITS OF LARVÆ.

Thrips larvæ feed almost entirely on young, tender foliage and on the surface of fruits. They conceal themselves in terminal buds (Pl. I, fig. 2), and often, as on the cherry, they attack the underside of leaves, usually near the prominent veins. They cause the leaves to become much contorted, ragged, and full of holes (Pl. II, fig. 1). The insects seem at times to take advantage of certain tendencies in the growth of plants on which they happen to feed. For example, newly opening pear or apple leaves show a tendency to roll from the sides inward and thrips find this inner protected surface a most desirable feeding place. In such a case the upper, inner surface is destroyed, and the leaf, instead of opening out, becomes rolled up tight and eventually dies. The insect thus secures the tenderest of leaf tissue for its food, and also protection in the folded leaf. (Pl. I, fig. 2.) Thrips often cause a deadening of the leaf margin, and in such cases the leaf is forced into an abnormal, often cup-shaped, growth. This is a very characteristic injury on pear trees. (Pl. I, fig. 3.) The feeding injury of thrips larvæ on fruits, especially prunes, is in a way superficial, but it seriously impairs the appearance of the ripened fruits and greatly lessens the value of the finished product. A prune grows to be larger than a grain of wheat before the dead calyx is sloughed off. Larvæ feed under protection of this dead calyx, and as a result an abrasion of the skin, the feeding injury, is noticeable, even on very small fruits. The wound appears first as a small brown spot which enlarges and produces a scab as the fruit matures. The seriousness of what at first might seem a small surface marking is more readily appreciated when one recalls that when prunes are being cured the tough, scabby spot does not shrivel up during the process of drying as does the flesh of the prune, nor does it assume a darker color as does the prune.

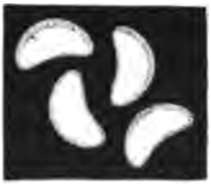
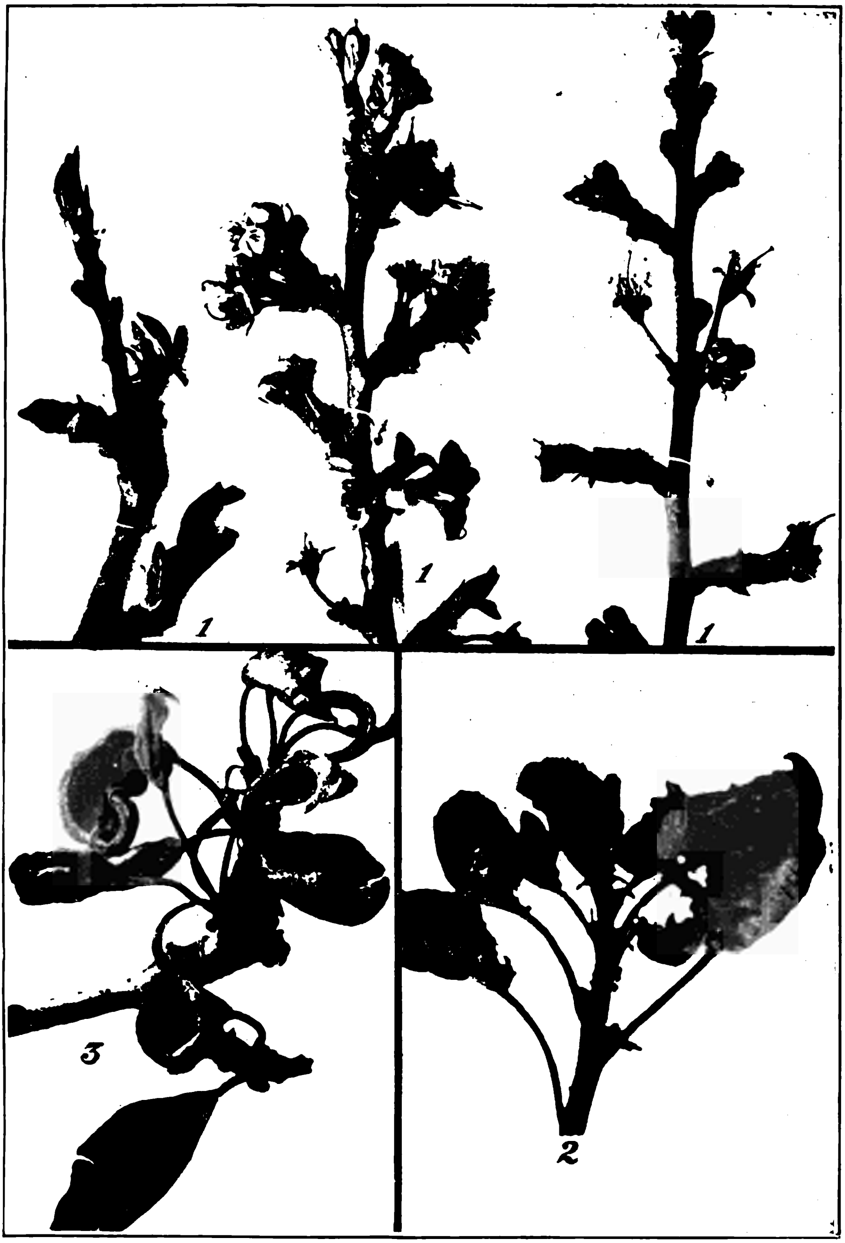


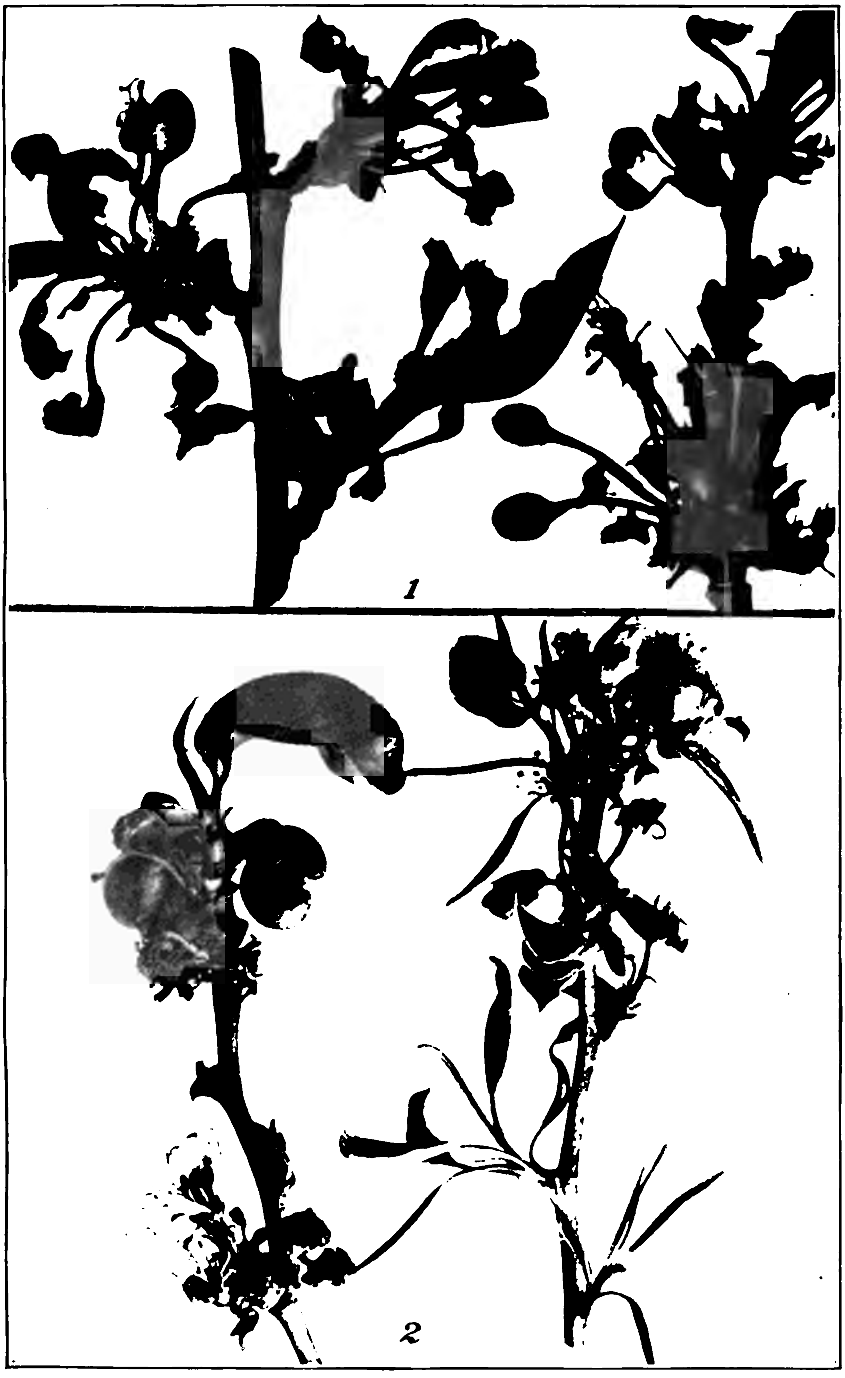
FIG. 2.—Eggs of the pear thrips (*Euthrips pyri*). Highly magnified (original).

Thrips larvæ are often carried by various means from the original food plant to other hosts, being blown, for example, from a tree to grass or weeds beneath. They have no wings and can not fly back to the tree. A few crawl up again, but most larvæ adapt themselves to the new plant until fully grown, when they, too, go into the ground. Many of the common weeds have thus been found supporting larvæ, although no full-grown thrips have ever been seen feeding or deposit-



WORK OF THE PEAR THRIPS (EUTHRIPS PYRI DANIEL).

Fig. 1.—Imperial prune, showing buds and blossoms injured by feeding of adult thrips. Fig. 2.—Unfolding leaves of Hemskirk apricot injured by young thrips. Fig. 3.—Madeline pear, showing cup-shaped deformities of the larger and rolling of the smaller leaves, the injury caused by young thrips. (Original.)



WORK OF THE PEAR THRIPS (EUTHRIPS PYRI DANIEL).

Fig. 1.—Black Tartarian cherry blossoms killed by adult thrips and leaves injured by young thrips. Fig. 2.—Bartlett pear, showing all except very late blossoms dead from thrips and leaves injured by feeding of young thrips. (Original.)

ing eggs on such plants. The insect has proved itself a strictly fruit-tree pest, and it is carried to weeds and lives on them or on other plants only by accident.

LIFE HISTORY AND HABITS.

THE EGG, THE OVIPOSITOR, AND OVIPOSITION.

The thrips egg is bean-shaped (fig. 2), light-colored, almost transparent, and is very large in proportion to the size of the abdomen when seen within the body of the adult female. It is about 0.33 mm. long by actual measurement.

The ovipositor (fig. 3) is made up of four distinct plates. Each plate is pointed, has a serrate outer edge, and is operated by powerful muscles and plates within the abdomen. The pairs on each side fit together along the inner edges with a tongue-and-groove-like structure, which in action renders possible a sliding back and forth, or sawing motion. The ovipositor is protected within a sheath in the ventral tip of the abdomen when not used, but before and during ovipositing it is lowered until almost at right angles to the body.

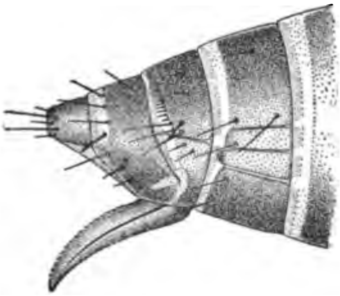


FIG. 3.—The pear thrips (*Euthrips pyri*): ovipositor and end of abdomen from side. Much enlarged (original).

Oviposition accompanies feeding. It seems necessary, indeed, that before the ovipositor can be inserted through the plant epidermis the thrips must first weaken or break an opening through this tissue with the mouth-parts. The successive operations of lacerating the plant tissue, lowering the ovipositor, placing an egg, and withdrawing the ovipositor require from four to ten minutes, and may be briefly described as follows: After making an incision with the mouth parts the insect moves forward, lowers and inserts the ovipositor, and by operating the tiny saws she makes a deep incision in the plant tissue. While the ovipositor is still deeply set in the plant, an egg is conducted through the cavity between the plates and deposited underneath the epidermis. The ovipositor is withdrawn and the egg is thus left deeply embedded within the plant. During the oviposition period one often finds a branch or a tree, or even many trees, on which almost all thrips are ovipositing at the same time.

The small, fragile, just-exposed blossoms, stems, and leaf petioles, and later the midribs and veins on the back side of the leaves, and still later even the leaf tissue itself, are the places preferred for ovipositing. A thrips always places her eggs in the tenderest of the plant's tissue. There is danger of the ovipositor getting caught if the tissue is hard. Also, it is necessary during egg development that the surrounding tissue be flexible and moist, for the egg covering is elastic and the embryonic thrips within increases in size very noticeably before the larva issues.

There is space within the adult insect's body for only a few eggs at a time—seven or eight. A thrips probably places only a few eggs during a single day. She feeds for a time, deposits an egg, and then moves to another place, and later to still other places, and these may be all on one or scattered on several trees. The adult thus spreads her progeny from tree to tree wherever she goes. Nothing seems to hinder thrips which may be set on ovipositing. They have been observed placing eggs at all hours of the day and night and under all conditions of weather. The period of oviposition lasts for several weeks, or during practically all of the life of the adult insects. Injury from oviposition is most conspicuous on cherry trees. Operating at the base of a cluster of fruits, a few thrips will cut several incisions and place as many eggs in a single stem. This so weakens the stem that it fails to perform its usual function, and the rapidly developing cherry soon becomes yellow, and falls. Thrips seem to prefer the cherry to other varieties of fruits as a place for ovipositing during the later season, and this fruit suffers severely from ovipositing, though it may escape the first feeding injury. The result is a heavy dropping of half-grown cherries, which in badly infested regions means almost the whole crop.

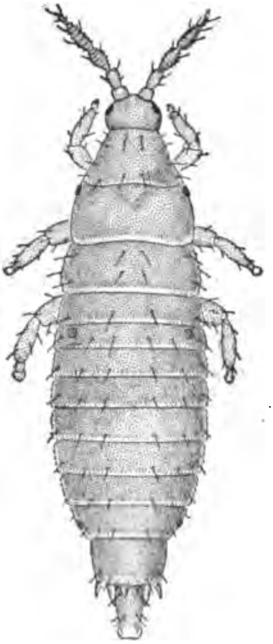


FIG. 4.—The pear thrips (*Euthrips pyri*): larva. Much enlarged (original).

Numerous leaf and blossom stems in which eggs had been placed were closely watched to determine the length of the egg stage. In many cases these stems became dry during confinement in the laboratory, and almost invariably from these no thrips issued. Eggs need moisture for their preservation and development, and young thrips must have tender and pliable tissue through which to emerge. The egg stage lasts, approximately, four days.

THE LARVA.

It is interesting to watch, with the aid of a strong lens, a young thrips issuing from the egg. The tiny incision in the stem of a blossom or leaf shows where an egg has been placed, and the enlarging egg within, causing a swelling in the plant tissue at the summit of which is the incision, indicates that the insect is about ready to emerge. The first sign of life is the appearance, pushing out from the incision, of the head with its bright red eyes. Little by little, and swaying backward and forward, the larva forces itself out until about one-half of the body is exposed, when first the antennæ and then one by one the pairs of legs are made free from their resting position against the body. Swaying backward and forward, with legs and antennæ waving frantically about, the insect pushes out of the egg cavity almost to its full length, whereupon, leaning forward it eagerly takes a hold with its newly formed feet, and, with a final effort, pulls itself free and walks rapidly away. From four to ten minutes are required for the insect to free itself from the egg. The young insect is almost transparent and the green chlorophyll particles taken into the stomach can be seen through the body wall. Growth is rapid from the beginning.

A very decided change takes place during the second larval stage (fig. 4). In about three weeks the insect reaches a size often larger than that of the fully matured insect. It then ceases to feed, falls to the ground, and enters the ground by some crack or wormhole. It goes down from 3 to 10 inches, according to the structure and condition of the soil, the usual depth being about 4 inches. Upon reaching a secure depth, the larva hollows out for itself a tiny spherical or oblong cell or it finds an exceedingly small natural cavity and shapes this for its convenience. The completed chamber has a hard, smooth inner wall, and it is about one-twelfth of an inch long, or just a little longer than the insect itself. The insect here spends the greater portion of its life. It remains for several months a quiescent, non-food-taking larva. Later the pupal changes are undergone, and lastly the adult insect appears before it issues forth to the tree. Larvæ collected from the ground on August 28 were active, and, strange to say, green chlorophyll matter, undigested food, which had been taken into the stomach several months before, was still present in their bodies. The insects are scattered through the soil from near the trunk to several feet from the tree.

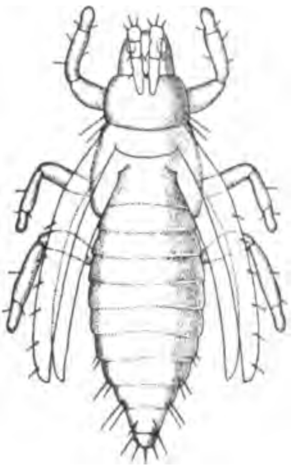


FIG. 5.—The pear thrips (*Euthrips pyri*): nymph or pupa. Much enlarged (original).

THE NYMPH OR PUPA.

The writer has not been able to determine how long the nymph stage (fig. 5) lasts, but it evidently extends over several weeks. Nymphs in all stages of development were collected during May and at intervals until the following February, but they are most common during December, January, and February. The writer has gathered nymphs from the ground early in May, but it is difficult to explain their presence there so early in the spring. It hardly seems possible that these were the still immature forms of the previous year, for by this time all adult thrips had left the trees. These nymphs were taken along with the larvæ, which had just entered the ground, and it might seem that they were hurrying through to produce a second generation; but to the writer's certain knowledge adults of a second generation did not appear on the trees. The nymph is active at all times. Wings develop from mere buds to long sacs which project backward along the sides of the body, and eventually reach beyond the tip of the abdomen.

THE ADULT.

The adult thrips (fig. 6) remain in the pupal chamber for days, and it may even be weeks before they issue forth to take up active life. How individual thrips force their way through the several inches of earth which lies above them is still a question. They come out, it seems, only after the ground has been thoroughly softened by rains, and it is evident, too, that they depend largely on the natural openings. They can not possibly use the backwardly bent mouth cone as a means of boring or biting their way out. They have several groups of spines and certain angular edges on the sides of the abdominal segments, however, which might be used in forcing a way through the soft soil. They also possess roughened, scoop-like structures—parts of the chitinous, hoof-like shell of the feet—which undoubtedly are used for digging.

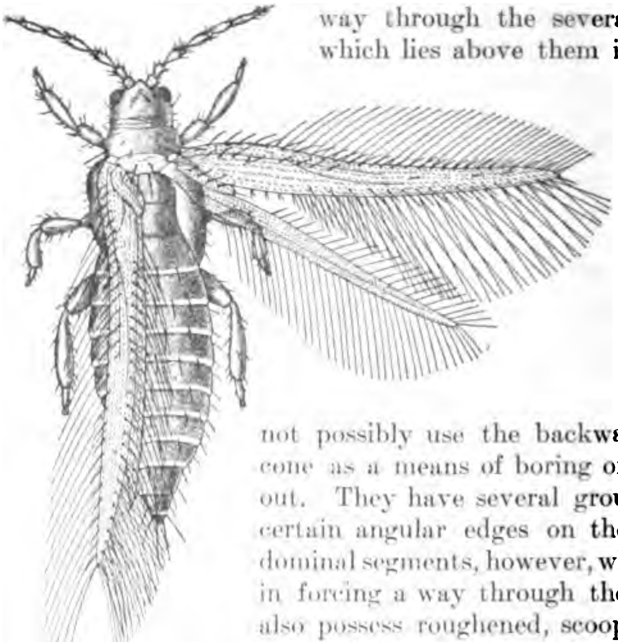


FIG. 6.—The pear thrips (*Euthrips pyri*): adult. Much enlarged (original).

Adult thrips appeared in alarming numbers in many Santa Clara Valley orchards in 1904, about February 24; in 1905 several days later, and in 1906 about March 1. They appear on the trees by millions and, it seems, all at about the same time. They feed and oviposit most actively during March and April, and by May 1 almost all have disappeared. No male individuals of the pear thrips have ever been collected; all have been females.

Adults may be present in an orchard for a few days and then suddenly almost all disappear. This is explained by their habits of migration as evidenced by the following observations: In a certain pear orchard which had been kept under daily observation for a week or more thrips had been abundant in blossoms and buds until suddenly one day all seemed to have disappeared. Upon closer examination, however, they were found congregating and walking around on the larger branches. This was about 3 o'clock in the afternoon. On the following morning hardly an individual could be found in the orchard. This manner of flight seems to be distinctly migratory. Thrips often leave their places of feeding just before sunset and hover around and over and later settle back on the same trees. This mode of flight is decidedly different from the migratory one. It occurs only at evening, and the writer has never seen the pear thrips in flight during the morning or during the middle of the day.

DESCRIPTION.

Euthrips pyri Daniel.

Measurements: Head, length 0.13 mm., width 0.15 mm.; prothorax, length 0.13 mm., width 0.2 mm.; mesothorax, width 0.28 mm.; abdomen, width 0.31 mm.; total length 1.26 mm. Antennæ: 1, 33μ; 2, 45μ; 3, 63μ; 4, 54μ; 5, 33μ; 6, 66μ; 7, 9μ; 8, 12μ; total, 0.31 mm. *Color* dark brown, tarsi light brown to yellow.

Head slightly wider than long, cheeks arched, anterior margin angular, back of head transversely striate and bearing a few minute spines and a pair of very long prominent spines between posterior ocelli. *Eyes* prominent, oval in outline, black with light borders, coarsely faceted and pilose. *Ocelli* are approximate, yellow, margined inwardly with orange-brown crescents, posterior ones approximate to but not contiguous with light inner borders of eyes. *Mouth-cone* pointed, tipped with black; maxillary palpi three-segmented; labial palpi two-segmented, basal segment very short. *Antennæ* eight-segmented, about two and one-half times as long as head, uniform brown except segment 3, which is light brown; spines pale; a forked sense cone on dorsal side of segment 3, with a similar one on ventral side of segment 4.

Prothorax about as long but wider than head; a weak spine at each anterior and two large, strong ones on each posterior angle; other spines are not conspicuous. *Mesothorax* with sides evenly convex, angles rounded; metanotal plate with four spines near front edge, inner pair largest. The mesonotal and metanotal plates are faintly striate. *Legs* moderately long, uniform brown except tibiæ and tarsi, which are yellow. Spines on tip of fore and middle tibiæ weak; several strong spines on hind tibiæ. *Wings* present, extending beyond tip of abdomen, about twelve times as long as wide, pointed at tips; costa of fore wings thickly set with from twenty-nine to thirty-three quite long spines; fore vein with twelve or fifteen arranged in two groups of three and six, respectively, on basal half of wing and a few scattering ones on distal part; hind vein with fifteen or sixteen regularly placed spines; costal fringe on fore wing about twice as long as costal spines.

Abdomen subovate, tapering abruptly toward the tip from the eighth segment; longest spines on segments 9 and 10; abdomen uniform brown, connective tissue yellow.

Redescribed from many specimens, including several cotypes from Miss Daniel.

Male unknown.

Food plants: Apricots, apples, almonds, cherries, figs, grapes, pears, prunes, plums, walnuts. The insect is found mostly on deciduous fruits.

Habitat: San Francisco Bay region, California.

METHODS AND NATURAL FACTORS IN CONTROL.

The study of the life habits of the pear thrips, as already given in detail, explains why certain artificial remedies are not entirely effective, and it also suggests other methods. Adults appear suddenly in late February and early March. They enter the opening buds and feed largely in protected places, and always on newly developing plant tissue. Destruction to buds can be accomplished in a very few days—it may be in less than a week. The fully developed wings of the insect permit of active flight and widespread distribution. Oviposition, extending through several weeks, permits of a widespread and a continuous feeding period for the new brood. Eggs are safely placed within the plant tissue. Larvæ feed largely in protected places while on the tree, and then seek shelter and spend many months in the ground. An individual of the species will spend about eleven months in the ground and one on the tree, although the whole period of infestation of trees by adults and larvæ may be about three months.

SPRAYS.

Exposed thrips, both adults and larvæ, can be killed by several of the contact insecticides, but sprays have not proved successful, because the spray mixture can not be forced into the very tender buds and blossoms where the thrips are, without injuring the plants, and, besides, all of the thrips can not be reached by a single spraying. It was found in the limited experiments of 1905 that thrips could be killed over any given area, but that within a few days the infestation would be as bad as though no spraying had been done. This is accounted for by the presence of those thrips which escaped the spray and by the new individuals which had migrated into the orchard.

It would be impossible for all persons to accomplish their spraying within the few days when the thrips are arriving on the trees. Larvæ are more easily killed than adult thrips, but as they feed largely within the leaf clusters they, too, are protected. Spraying to kill larvæ would necessarily be done after the serious injury from adults had been effected. It might be possible to obtain some results by applying a poisonous spray, but the ever newly unfolding leaf surface, upon which the insects could feed and which would not be poisoned, would render this kind of spray almost useless.

CULTIVATION.

There is some ground for believing, although the evidence is not conclusive, that thorough cultivation will figure largely as a means of control for the pear thrips; but even here the treatment must cover areas of considerable extent. Thrips larvæ in the ground are mostly within reach of the plow, being usually found within 5 inches of the surface, although a few may go deeper. On uncultivated areas they may be found within 2 or 3 inches of the surface. Thrips are entering the ground mostly during the last two weeks of March and during April, a period when the most active cultivation of the year is carried on. But the insects are very active at this time, and if they are only disturbed and not killed in the mechanical stirring of the soil they simply find a new place to hide and perhaps go a little deeper into the ground. From the following evidence, however, it is quite obvious that careful spring cultivation is helpful. A certain row of cherry trees which was badly infested with thrips during 1905 was kept under constant observation for several months because it represented various interesting conditions. The trees bordered a roadway and were for this reason cultivated only on one side. There was a strip of land perhaps 3 feet wide extending on either side of the row, which, though uncultivated, was not hardened like the roadway. In February and March, 1905, the trees in question were very badly infested, were stripped of all their fruits, and left with pale, ragged leaves. Adults were numerous. Many eggs were deposited and larvæ by thousands matured, dropped down, and entered the ground. These larvæ were actually seen entering the soil, mostly during the month of April. During April and May they were readily found in the ground several feet from the tree as well as near to its trunk. They were scattered about generally, regardless of cultivation, except that the many individuals which were unable to penetrate the hard gravel road crawled off to the side. They did not go deeper than 3 or 4 inches in the uncultivated strip near the trees, while in the well-cultivated soil they were often found 6 or 7 inches below the ground surface. They could be found easily anywhere, in April, just after entering the ground. After the spring and early summer cultivating, however, almost none could be found in the deeply cultivated soil, but they were as common as ever in the uncultivated ground. A dozen or more thrips were often collected from a small clod about an inch and a half in diameter. Small uncultivated areas may be found in almost any orchard, and it is a fact that a few square yards of ground can harbor a very large number of thrips.

Cultivation methods, however, as a means of control, can be only partially effective at best. One can not kill all of the thrips in the ground even with the most careful cultivation, and there are always men who can not or will not cultivate at the proper time. Then, too, there are areas along fences, ditches, etc., which can be cultivated only with great difficulty. What is even more important, certain kinds of soils—adobe and clays—can be cultivated only under certain conditions to be kept mellow and loose. The present manner of cultivation in the Santa Clara Valley offers almost ideal conditions for the thrips, in that the insect is left undisturbed during almost the entire period occupied by the resting stage—from June until the following February.

Thrips are in the ground all of this time, and for the most part within reach of the cultivator, but they mature and arrive on the trees in March and April, before spring cultivating is begun.

NATURAL ENEMIES.

The pear thrips is largely protected from ordinary predaceous and parasitic insects, because it spends so long a time hidden away in the ground. A successful parasite must in a way parallel the life of its host, and we have found no insect which thus follows the pear thrips. Raphidians, or snake flies, their commonest enemies in the Santa Clara Valley, feed rather on the younger forms than on the fully developed insects, and they do not appear early enough in the spring to constitute an effective check to the pest. To be competent thrips killers they would have to feed on other insects for perhaps ten months in the year and then, when thrips appear, suddenly change their diet and later, after thrips have gone into the ground, as suddenly change back again to aphides or to something else. Such feeding habits are not to be expected in a predaceous species.

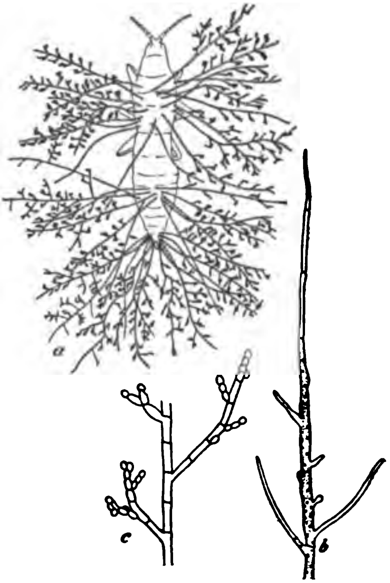


FIG. 7.—*Cladosporium* sp., a fungus which attacks the pear thrips: *a*, active fruiting stage on adult thrips; *b*, branching mycelia; *c*, forming spores. *a*, much enlarged; *b*, *c*, highly magnified. (Original.)

Ants were at one time thought to be doing much good as an enemy of the thrips. A certain orchardist brought in an ant with a thrips impaled in its jaws—the evidence complete. After a careful investigation, however, it was found that only a very small percentage of ants were actually killing thrips. Four hundred ants were examined as they descended a thrips-infested tree. Twelve of these carried something in their jaws and only 4 of these objects were thrips. Thus only 1 per cent of the ants on the tree were actually killing thrips and carrying them down. It has been a common observation among orchardists, however, that thrips are not common where ants are unusually abundant.

Spiders and mites are active enemies of thrips. In some of our breeding cages almost all of the thrips would at times be killed by some small spider or mite which had gained an entrance. The writer has observed a red mite (*Rhyncholophus* sp., determined by Mr. Nathan Banks) actively engaged in feeding on the onion thrips (*Thrips tabaci*

Lind.). Both the thrips and the mite were very common in large onion fields, covering several hundred acres. A mite would be seen to approach and grasp a thrips with its front pair of legs and, inserting its proboscis, suck out the body juices of its prey. A single mite was often observed thus to kill several thrips within a very few minutes. The writer strongly suspects that some mite preys on the younger stages of the pear thrips while it is in the ground. This would be entirely possible, and mites are commonly found in the grass and in the ground.

A fungus, presumably parasitic, has been endemic among thrips during the seasons 1905 and 1906. In its different stages it lives on both young and mature thrips, and in a way parallels the life of its host. During the spring of 1905 thrips larvæ were often observed to be thickly infesting a tree, and after these had disappeared, presumably having gone into the ground, none or but few living ones could be found. Many larvæ, too, seemed to leave the tree before they had reached full growth, and within breeding cages these larvæ were seen to die as the direct result of the parasite. Projecting from their bodies were to be seen the tiny fruiting conidiophores of the fungus. Adult thrips were seen to be attacked by another form of the parasite during the spring of 1906. The past two seasons have offered almost ideal conditions for the development of the fungus, enabling it to become quite widespread.

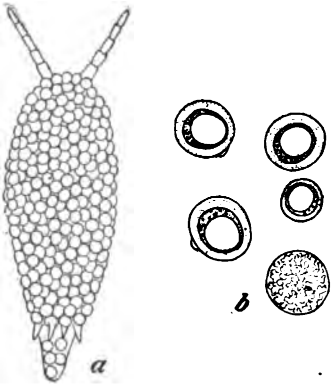


FIG. 8.—*a*, Resting spores of a fungus found within dead thrips larva, much enlarged; *b*, same spores, highly magnified. (Original.)

The life history of the fungus has been determined only in part. The heavy-walled resting spores, the dormant stage, are found within larvæ and adults in the ground; never, thus far, in pupæ in the ground or in individuals on the tree. Dead larvæ from the ground show that the internal body organs have all been displaced by the fungus, and in most cases the body contains only a mass of the heavy-walled spores. The transition which takes place in the formation of these spores is as yet not clear, but there seems to be a general breaking up of the fungus *hyphæ* within the thrips' body. In one well-prepared specimen there was an indistinct grouping of particles around many centers. These were presumably the forming spores, for in the next stage the formation of such spores was complete. These heavy-walled spores may be found nearly the whole year through, although they are especially abundant from May until the following February.

In the conidiophore stage on the tree the fungus hyphæ break forth in groups from between the body segments and extend out as long slender threads, which in turn branch and form numerous fruiting organs (fig. 7). This stage of the fungus has been taken only from adult thrips on the tree and not from the larvæ, and it has been found present almost everywhere that the pear thrips has been collected.

There is no doubt that the fungus spends a part of its life on the tree and a part in the ground, the rapidly fruiting stage among the active thrips and the heavy-walled dormant stage within the hibernating individuals in the ground; but we can only surmise how it is carried from one to the other. The bodies of the larval thrips within the ground are all absorbed by the fungus and naturally, therefore, the spores must be carried to a new host before they can germinate to any great extent. We have found adult thrips in the ground whose dead bodies contained only a few spores and others which developed some of the external mycelial growth within their cells. If this were often the case, and these individuals in the ground produced fruiting spores as they do on the trees, it would be an easy matter for healthy individuals in coming from the ground to become accidentally infested and to carry the parasite up to the tree where, because of the gregarious habits of the insect, it would spread rapidly.

The fungus grows readily in the nutrient agar under ordinary conditions and seems to retain its virulence and can be transferred from cultures to the living thrips. The fungus may prove to be a check for the pear thrips, but its effectiveness is uncertain because it is so subject to climatic conditions.

Mrs. F. W. Patterson, of the Bureau of Plant Industry, Department of Agriculture, has determined this fungus to be a species of Cladosporium. Although we have not seen any one of the heavy-walled resting spores actually germinate and develop into a colony, yet by planting such spores in nutrient agar we have produced a fungus which proves to be the same as that which developed later from spores taken from an infested thrips directly from the open field. Mrs. Patterson notes a difference between the two fungi, which she attributes to the fact that the one is grown on nutrient agar, while the second matured on its natural host. She also remarks that "it is extremely doubtful if any species of this genus has been reported as an entomogenous parasite." From our observations, however, it would seem to be a true parasite, although our chain of evidence is not yet complete.

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BUREAU OF ENTOMOLOGY—BULLETIN No. 68, Part II.

L. O. HOWARD, Entomologist and Chief of Bureau.

PAPERS ON DECIDUOUS-FRUIT INSECTS AND INSECTICIDES.

THE SPRING CANKER-WORM.

BY

A. L. QUAINTANCE,

In Charge of Deciduous Fruit Insect Investigations.

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U. S. D. A., B. E. Bul. 68, Part II. D. F. I. I., July 6, 1907.

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE SPRING CANKER-WORM.

(*Paleacrita vernata* Peck.)

By A. L. QUAINTANCE,

In Charge of Deciduous Fruit Insect Investigations.

INTRODUCTION.

Two species of canker-worms in the United States, the spring canker-worm (*Paleacrita vernata* Peck) and the fall canker-worm (*Alsophila pometaria* Harr.), are often very troublesome pests in apple orchards, infesting also the elm, cherry, and, to a less degree, a few other trees. These insects, though widely distributed, usually occur in injurious numbers quite locally, infesting often but one or two orchards in a neighborhood where conditions have been favorable for their development. The females of both species are wingless, hence their dissemination is very slow. The insects are doubtless distributed mostly on nursery stock in the egg stage, or locally the larvæ and moths may cling to clothing of persons, or may be distributed by teams visiting the infested orchards.

Old orchards which have been in sod or have not been cultivated for many years and which are not sprayed with arsenicals furnish ideal conditions for the multiplication of canker-worms when the latter are once established. Frequently such orchards are defoliated each spring, with the result that the injury to the trees prevents the formation of fruit buds, and after a few years of such injury the trees will begin to die. While certain weather conditions and the natural enemies of canker-worms may often greatly reduce the number of these insects, energetic steps on the part of the orchardist are usually necessary to insure the complete destruction of the pests and to permit the trees to resume their normal fruit production. In the great majority of cases, if not in all, canker-worms are practically limited to orchards which are neglected as to spraying and cultivation, either practice usually serving to keep them so reduced in numbers that their injuries are inconsequential.

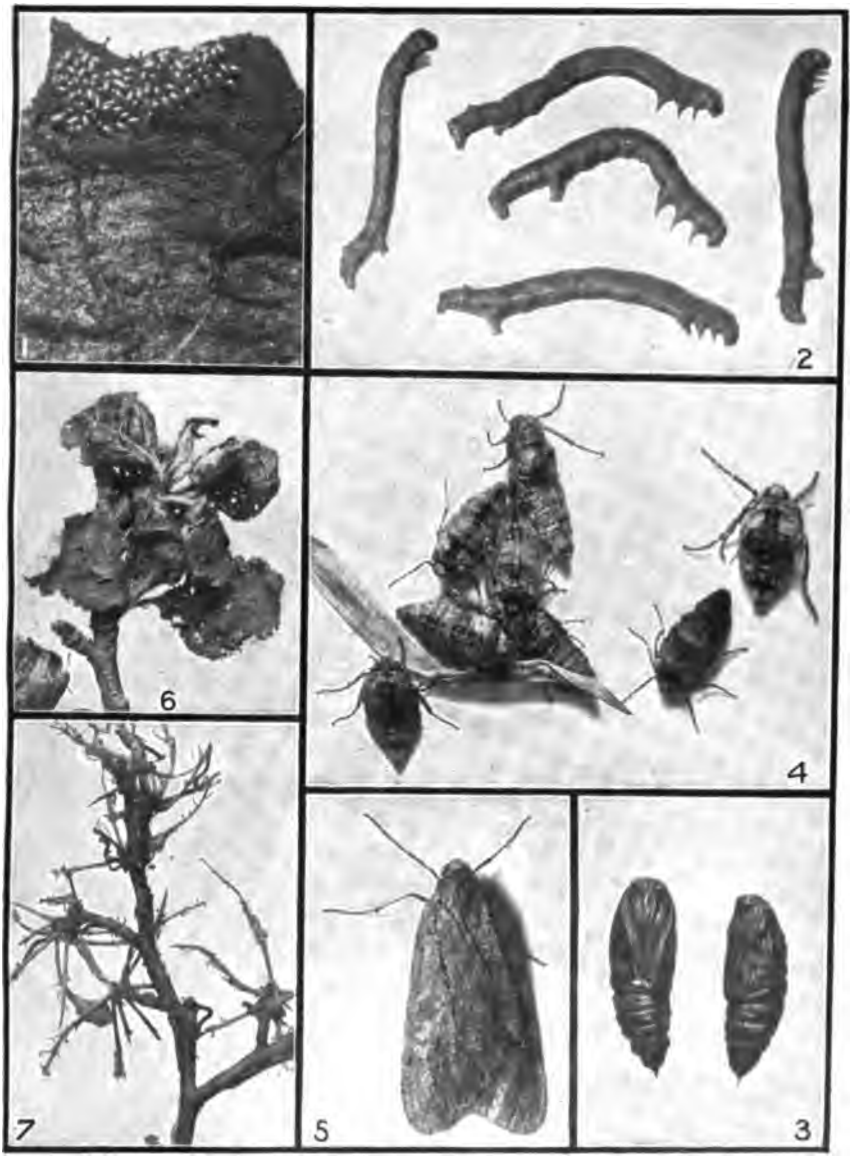
Complaints of both fall and spring canker-worms are frequently received by the Bureau of Entomology. Correspondents often report that they are unable to protect their trees by the use of arsenicals, and the opinion has at times been expressed that these insects can not be destroyed by arsenical sprays. While it has often been stated in the literature on canker-worms that they are more resistant to poisons than many other species of insects, yet there is no doubt that they may be readily killed by thorough use of poisons. In most cases the poor results from spraying are evidently due to failure to make thorough applications of the spray, the large size of the trees and the unfamiliarity of the orchardist with spraying operations often contributing to this end.

In the present brief article the life history and habits of the spring canker-worm are given, together with results of practical work in its control. The life history and habits of the fall canker-worm practically parallel those of the spring species, except that the great majority of the moths of the former species emerge and oviposit in the fall. The operations of spraying and plowing herein discussed will be equally effective in its control.

LIFE HISTORY AND HABITS.

There is but one generation of canker-worms each year. After obtaining their growth on the trees in the spring, the larvæ enter the soil to a depth of from 2 to 5 inches, and after making an earthen cell transform to pupæ (see Pl. III, fig. 3), in which condition they remain until the following spring. Early in the spring, or even during warm spells in winter, the pupæ transform to moths, which make their escape from the soil and go to the trees. The males are winged, as shown in Plate III, figure 5, but the females are destitute of wings, as illustrated in Plate III, figure 4. In ovipositing the females climb the trees and place their eggs in irregular masses under loose bark scales, in cracks in the bark, in crotches of limbs, etc., as shown in Plate III, figure 1, which illustrates an egg mass which was placed on the underside of a bark scale. The number of eggs in an individual mass varies greatly. Females taken presumably before oviposition had begun deposited eggs in confinement, the number to a mass varying from 17 to 119, with an average for 12 masses of 47.

An individual egg is elongate-elliptical in outline, somewhat resembling a hen's egg in miniature. The average dimensions of ten recently deposited eggs were found to be 0.69 by 0.42 mm. When first deposited the surface is shining, pearly white, but in the course of a few hours the egg takes on a yellowish-green color, in certain lights showing a golden, greenish, or purplish iridescence. As the embryo approaches maturity it becomes very evident and lies curled around just within the shell, its cephalic and caudal ends together, the egg-



STAGES AND WORK OF SPRING CANKER-WORM (PALEACRITA VERNATA PECK).

Fig. 1.—Egg mass on bark scale. Fig. 2.—The larvæ or canker-worms. Fig. 3.—Pupæ. **Fig. 4.—Female moths.** Fig. 5.—Male moth. Fig. 6.—Work of canker-worms on apple leaves when small. Fig. 7.—Later work of the larvæ, only the midribs of leaves being left. **Figs. 1-5,** considerably enlarged; figs. 6, 7, reduced. (Original.)

shell becoming more or less concave centrally. Shortly before hatching the eggs become quite dark, due to the color of the larva within. Eggs secured from females in confinement on the nights of March 8, 10, and 12, and kept under out-of-door conditions in the insectary yard at the Department of Agriculture, Washington, D. C., were hatching April 10, 11, and 14, respectively, giving for this stage a fairly uniform period of thirty-two to thirty-three days. The effect of warm weather upon the development of the embryo may be judged from the fact that eggs kept in the insectary at a temperature of 65 to 70° F. hatched in about eleven and one-half days.

When just hatched the spring canker-worm is quite small, measuring but 1.25 to 1.5 mm. in length, varying with the extension of the body. The head is about 0.25 mm. wide, which slightly exceeds the width of body across thoracic segments. The head and shield are shining black, and the body above dark olive-green, with a distinct central longitudinal white stripe centered with narrow interrupted lines of the same color as the body. Along each side is a wide irregular white stripe, including the spiracles and adjacent tubercles. Below, the body is dark yellowish or brownish in color. The thoracic legs are stout and dusky exteriorly. There is a single pair of prolegs on the sixth abdominal segment and a pair of anal prolegs.

The larvæ come from the eggs about the time the leaves of the apple are pushing out, and the latter are at once attacked. At first only small holes are eaten through the leaves, but later, as the larvæ grow, the entire leaf substance save the midrib is devoured. (See Pl. III, figs. 6, 7.)

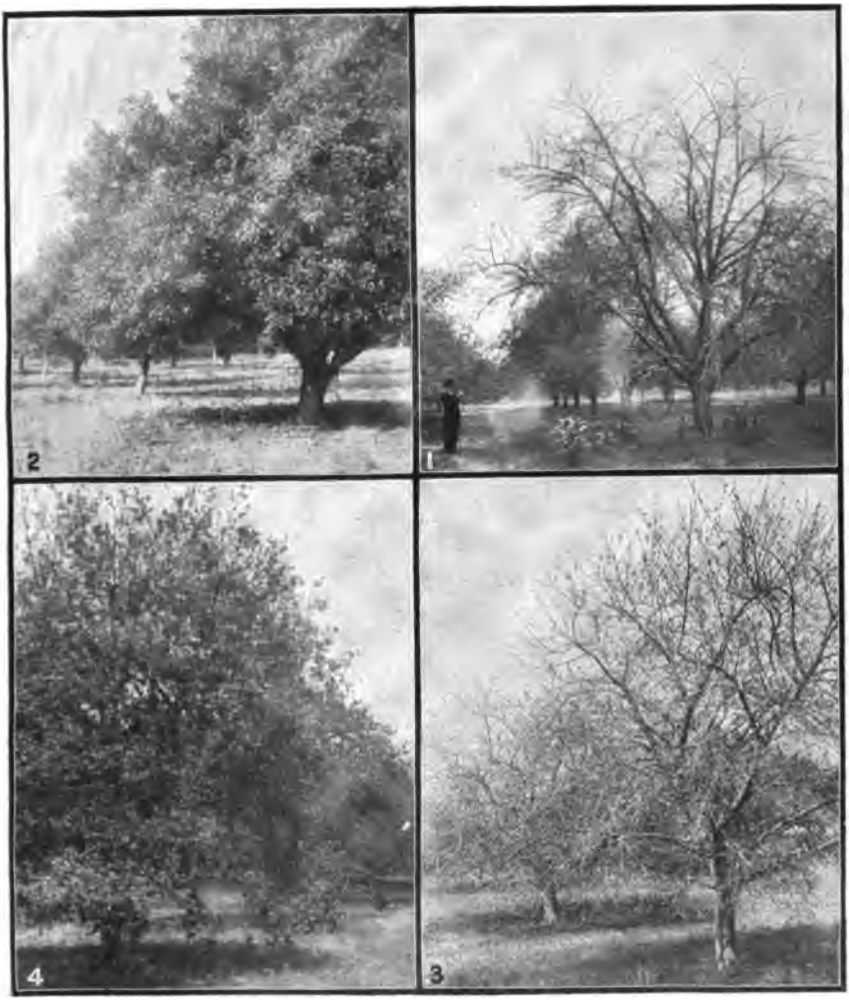
After three or four weeks of feeding, the time varying much with the temperature, the larvæ have become full grown. They then measure from 18 to 23 mm. (0.7 to 0.9 inch) in length. Considerable color variation is likely to occur, some specimens being ash-gray, green, or yellow, but the predominating color is dark greenish olive or blackish. There are two pale narrow lines down the back, centered with a broader dark stripe and a whitish stripe along each side. (See Pl. III, fig. 2.) The larva of this species is readily distinguished from that of the fall canker-worm by the fact that the former has but two pairs of prolegs, while the latter has three, the first pair, however, on the fifth abdominal segment, being more or less reduced.

Newly hatched larvæ placed on apple trees under a large wire cage in the insectary yard April 12, 1905, had matured and were entering the ground for pupation by May 8, and by May 11 all had disappeared from the trees. This gives twenty-seven to thirty days for the larval existence. The egg and larval stages together require some two months, and the remainder of the year, except the time spent in the adult condition before ovipositing, is passed in the pupal stage in the soil. As has been stated, the insect pupates from about

2 to 5 inches below the surface of the ground and may be readily destroyed by thorough plowing and cultivation during the summer and fall.

DEMONSTRATION WORK IN CANKER-WORM CONTROL.

For several years the spring canker-worm has been quite troublesome in a few old orchards in northern Virginia and very little headway had been made by the owners of the orchards in its control. In the spring of 1905 Dr. John S. Lupton, of Winchester, Va., desired the assistance of the Bureau of Entomology in freeing from this pest his large orchard of 30-year-old Newton pippin trees, which had been defoliated to a greater or less extent for three or four seasons. The orchard had been in sod for years and no recent spraying had been done for the codling moth. Under these conditions the canker-worms had been able to multiply with practically no interference and had become exceedingly abundant, 50 per cent of the trees being practically defoliated and the others more or less so. A plan of treatment was submitted to Doctor Lupton, which was carried out by him under the writer's supervision. This treatment consisted in a thorough spraying of the orchard with Paris green at the rate of 1 pound to 75 gallons of water (plenty of lime being added to lessen danger of injury to the foliage), the thorough plowing of the orchard during the early summer, and its subsequent cultivation during that season. Only one application of poison was made, and not until much later than was desirable, the larvæ being already from one-half to three-fourths grown, many trees having been practically defoliated. Nevertheless, the treatment checked further defoliation and within two to three days the larvæ had largely disappeared. That the majority were poisoned was evident, since upon later examinations pupæ were exceedingly scarce, even under trees from which the leaves had been almost stripped. During early August the orchard was thoroughly plowed, special pains being taken to break up the soil under the trees. Late in the fall the worst infested portion of the orchard was again plowed, and at right angles to the direction followed in the first plowing. The rest was plowed early the following spring, the whole being prepared for corn, which later was planted, receiving necessary cultivation during 1906. As was quite evident in the spring of 1906, the thorough spraying with Paris green and plowing of the orchard had destroyed the great majority of the insects. In the early spring of 1906 bands of a sticky preparation placed around the trunks of trees which had been practically defoliated in 1905 caught not more than two dozen specimens of adults in all, and larvæ were very difficult to find later. That the absence of the insects in this orchard is to be attributed solely to the spraying and plowing and not to unfavorable weather conditions or the influence of parasitic



TREES DEFOLIATED BY SPRING CANKER-WORMS AND EFFECTS OF TREATMENTS.

Fig. 1.—Defoliated trees in Lupton orchard. Fig. 2.—The same trees a year later. Fig. 3.—Defoliated trees in the Purcell orchard. Fig. 4.—An adjacent row of trees protected by two applications of arsenate of lead. (Original.)

and predaceous enemies is evident from the fact that in a near-by orchard, untreated, the insects were excessively numerous, completely defoliating the trees during the spring of 1906. Figure 1, Plate IV, is from a photograph of trees in the worst infested portion of the Lupton orchard in 1905, and shows the injury that had been done before the application of the Paris green spray. The condition of these same trees, but looking in another direction, on June 9, 1906, is shown in figure 2.

During the spring of 1906 spraying work against canker-worms was also carried out in another orchard near Winchester consisting of 30 acres of 35-year-old Baldwin trees. This orchard also had been entirely neglected as to plowing and spraying for many years past, and for some years most of the trees had been completely defoliated by the spring canker-worm, some of them and portions of others being dead. Arrangements were made to spray a portion of the orchard, though it was not considered practicable by the owner to have the ground plowed. Arsenate of lead was used as a poison and applied at the rate of 3 and 5 pounds per 50 gallons of water for the first and second applications, respectively. At the time of the first application the leaves were well out, being from three-fourths of an inch to an inch in diameter. The canker-worms had almost all hatched, very many being in the second stage, and were literally swarming over the trees. The second application was made May 5, most of the larvæ at this time being from one-half to three-fourths grown, the untreated trees being already nearly bare of leaves. The treated trees, while showing some injury from the larvæ, especially in the higher parts, were in almost full foliage, though subject to infestation from adjacent trees. The second application largely protected the trees from further injury, and there is no doubt that if the entire orchard had been treated the insects would have been practically exterminated. Figure 3, Plate IV, shows the defoliated condition of untreated trees June 9, after the larvæ had all disappeared, and the condition of sprayed trees in an adjacent row is shown in figure 4 on the same plate.

RECOMMENDATIONS.

Orchardists having canker-worms to contend with may confidently expect to practically eradicate them in the course of one or two seasons by following the methods above described, namely, thoroughly spraying the trees with a strong arsenical and thoroughly plowing the ground during the summer. If Paris green is used, this should be applied at the rate of 1 pound for each 100 gallons of water, and unless used in Bordeaux mixture there should always be added the milk of lime made from slaking 4 or 5 pounds of good stone lime. Arsenate of lead may be used at the rate of 6 to 10 pounds to 100 gallons of water or Bordeaux mixture, and because of the strength at which it may be used without injury to foliage and its excellent sticking qualities it is to be preferred to other arsenicals for canker-worms. At least two applications of the poisoned spray should be made; the first as the fruit buds are exposed, or just as the foliage is pushing out, but before the blossoms open, and the second in eight to ten days, or at once after the blossoms have fallen. In bearing orchards the second treatment is the principal one for the codling moth, and if the poison be used in Bordeaux mixture the two applications of this combined insecticide and fungicide will largely protect the trees and fruit from canker-worms, the codling moth, and other leaf-feeding insects, and will lessen apple scab.

While it may often appear impracticable to spray some orchards on account of the height of the trees, most orchards may be plowed and cultivated, and this work should certainly form a part of the plan of canker-worm eradication.

Another important method of protecting high orchard and other trees which it is impracticable to spray is the employment of special protectors, such as bands of cotton, or sticky substances. These are placed around the trunk of the tree near the base, and are used to prevent the ascent of the wingless females to deposit their eggs, or the ascent of any larvæ from eggs deposited below the bands or which have fallen from the trees. Sticky substances, such as printer's ink, tar, bird lime, and certain proprietary preparations, are best. On account of the danger of injury to the trees, these are best applied on strips of paper 5 or 6 inches wide and of sufficient length to go around the tree. The loose bark should first be scraped from the trunk where the band is to be applied, and if a light band of cotton batting be first fastened where the paper band is to be placed this will effectually prevent the insects working up beneath the sticky paper band. Cotton batting may also be used, the trunk being encircled with a strip 4 or 5 inches wide. This is tied with a string at the lower edge and the band then turned downward. This will be effective so long as it remains fluffy, but usually requires renewal after heavy rains. Whatever form of protector is used must be applied quite early in the spring, at least six or eight weeks before the apple buds are due to burst, as the moths come out very early, sometimes even during warm spells in the winter.

The methods of control given above are equally applicable to the fall canker-worm, except that in the use of bands to prevent the ascent of moths these must be applied in early fall, since the moths of this species oviposit mostly during that season.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 68, Part III.

L. O. HOWARD, Entomologist and Chief of Bureau.

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE TRUMPET LEAF-MINER OF THE APPLE.

BY

A. L. QUAINTANCE,

In Charge of Deciduous Fruit Insect Investigations.

ISSUED OCTOBER 15, 1907.

WASHINGTON:
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FIG. 9. Trumpet leaf-miner of the apple (*Tischeria malifoliella*); Adult, larva, pupa, details 25

U. S. D. A., B. E. Bul. 68, Part III.　　　　D. F. I. I., October 15, 1907.

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE TRUMPET LEAF-MINER OF THE APPLE.

(*Tischeria malifoliella* Clemens.)

By A. L. Quaintance,
In Charge of Deciduous Fruit Insect Investigations.

During 1905 this species became unusually abundant in the District of Columbia and in localities in adjacent States. Specimens of mined apple leaves were received from Afton, Va., Newark and Woodside, Del., Cheltenham, Pa., and Vermont. Judging from the condition of the leaves sent, the insect in these several places was much less abundant, however, than in the immediate vicinity of Washington. During 1906 the insect was again exceedingly abundant in the environs of Washington, was the subject of further complaint from Delaware, and was received from Connecticut.

HISTORY.

This species was described in 1860 by Clemens in the Proceedings of the Philadelphia Academy of Sciences, Volume XII, page 208, from material presumably from Pennsylvania. Interesting observations concerning its food plants are presented by Chambers in the Canadian Entomologist, Volume III (1871), page 208; Volume V (1873), page 50, and Volume VI (1874), page 150. Additional notes are given by him in the Cincinnati Quarterly Journal of Science, Volume II (1875), page 3; in Bulletin U. S. Geological and Geographical Survey, Volume IV (1878), page 107, "Tineina and their Food Plants," and in Psyche, Volume III (1889), page 68. Messrs. Frey and Boll, in Stettiner Entomologische Zeitung, Volume XXXIV, page 222, note its occurrence in Germany on apple imported from this country. The insect has been occasionally mentioned by Lintner in the reports of the New York State Entomologist and elsewhere, and is the subject of an article with bibliography in his Eleventh Report. Dr. E. A. Brunn, in the Second Report of the Entomological Department of Cornell University (1882), in a paper on the Tineidæ infesting the apple trees at Ithaca, N. Y., gives an account of the insect with figures of moth, larva, and mines in apple leaf. A more extended account is given by Dr. C. M. Weed in the Fifteenth Report of the Illinois State Entomologist (1889), pages 45–50; and it is mentioned by Lugger in Minnesota Experiment Station Bulletin 61 (1898), page 316, and later (1903), by Washburn, in Minnesota Bulletin 84, page 66. In Bulletin 180 of the Michigan Experiment Station (1900), page 125, and Special Bulletin 24 of the same institution (1904), page 22, the species is the subject of short illustrated articles by Pettit; and it is also discussed by Lowe in Bulletin No. 180 of the New York Agricultural Experiment Station (1900), page 134. In 1906 brief mention is made by C. P. Close of the occurrence of this species in central Delaware (Bul. 73, Delaware College Agric. Exp. Station, p. 18), where it is said to have been increasing for several years past.

The above includes the important references to this species so far as the writer has been able to determine.[a]

DESCRIPTIVE.

The mine.—The mines occur exclusively on the upper surface of leaves, beginning at the point of deposition of the egg as a narrow, often curved line, gradually or suddenly enlarging in isolated and typical examples, and finally having the outline of a trumpet or mussel shell (see Pl. V). Completed mines vary much in shape and size, but will average, perhaps, in the more typical examples one-half inch long by one-fourth inch wide. There is considerable irregularity in the feeding habits of the larvæ, and blotch mines are often produced, the narrow linear portion being frequently more or less obliterated. In many mines crescent-shaped patches of white cross the linear portion, extending often well into the body of the mine. Unless held to the light the mine is scarcely noticeable from the lower surface of apple leaf, but above the blistered epidermis varies in color from whitish to dark brown, and the spotted appearance of badly infested leaves is noticeable some distance from the trees. Injury is confined principally to the palisade layer of cells immediately below the epidermis of the upper surface of the leaf. The position of the mine on the leaf is quite variable, but it does not usually cross the larger veinlets, extending more or less parallel with them.

The egg.—The eggs of *Tischeria malifoliella* are regularly elliptical in outline, somewhat convex centrally, but flattened around the margin, which area is more or less wrinkled. When first laid they are greenish yellow in color and somewhat translucent. In some lights they are irridescent, as are the empty egg shells. One or two days previous to hatching they become comparatively conspicuous, the embryo being central and the whitish margin showing plainly against the dark color of the leaf. The empty shells are white and mark the beginning of the mine. The average size (based on measurements of five eggs) is 0.34 mm. by 0.54 mm. The eggs are attached closely to the leaf, usually in furrows along a veinlet, but occur more or less promiscuously. This stage has not previously been described.

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[a] Since this article was prepared this species has been well treated by Mr. C. D. Jarvis, in Bulletin 45 of the Storrs, Connecticut, agricultural experiment station.

The larva.—The larva (fig. 9, *c*) upon hatching measures about 0.7 mm. in length. The head is brownish, the rest of the body whitish, except cervical and anal shields, which are dusky. Full-grown larvæ will average 5 mm. in length by 1 mm. in width across the third thoracic segment. The head is about 0.5 mm. wide, retractile, bilobed, brownish or even black in color. The general color of the body is light green, except cervical and anal shields, which are brownish. The body is flat, with the segments very distinct, and tapering caudad from the second or third segment, the last three segments rounder and narrower than the preceding. Thoracic segments with three long setæ on each side; succeeding segments with two setæ on each side varying considerably in length; at caudal end there are numerous shorter curved setæ. Thoracic legs absent. Abdominal and anal legs marked by five pairs of crochets (see fig. 9, *c*, *d*).

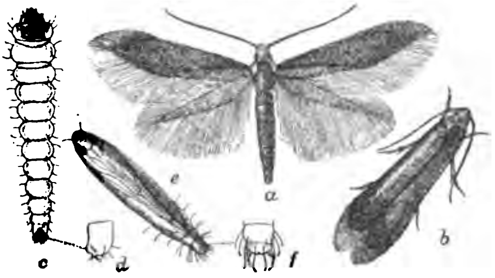

FIG. 9.—Trumpet leaf-miner of the apple (*Tischeria malifoliella*): Adult, larva, pupa, details.

The pupa.—The pupa is rather variable in size, the average of five being 3.35 mm. by 0.95 mm. The color when first formed is rather uniformly pea green, later becoming much darker, varying with age. The general color of the thoracic region and head is dark brown to blackish. The abdomen is dark green, yellowish caudad; the caudal margin of the rather distinct segments is brown. Leg and wing sheaths free; tip of third pair of legs reaching to cephalic border of third segment from last. The antennal sheaths reach the cephalic margin of the fifth segment from last. The spiracles are on slight conical elevations, and on each side of abdomen, ventrad of spiracles, is a row of long slender setæ, a pair to each segment. Cremaster of two stout short projections, slightly curved at tip. Head obtusely rounded, without horn-like processes, but with a pair of slender setæ. This stage has not hitherto been described, the description given by Weed being evidently that of the pupa of some other species. (See fig. 9, *e*, *f*.)

The adult or moth.—The description given by Clemens is as follows: "The head and antennæ shining, dark brown, face ocherous. Fore wings uniform, shining, dark brown with a purplish tinge, slightly dusted with pale ocherous; cilia of the general hue. Hind wings dark gray; cilia with a rufous tinge." (See fig. 9, *a*, *b*.)

FOOD PLANTS.

In his original description Clemens gives the food plant as apple. Chambers states that he bred it from leaves of different species of haw (Cratægus), sweet-scented crab (*Pyrus coronaria*), blackberry (*Rubus villosus*), and raspberry (*Rubus occidentalis*), and adds that it probably mines other species of Rosaceæ. Later Clemens says that this species, as well as certain others, feeds indifferently on leaves of Cratægus, Prunus, and Malus.

In 1873 Messrs. Frey and Boll described *Tischeria ænea*, bred from *Rubus villosus*, and *Tischeria roseticola* from *Rosa carolina*. In the Cincinnati Quarterly Journal of Science Chambers adds the dewberry (*Rubus canadensis*) to the food plants of *Tischeria malifoliella*, and does not consider *T. ænea* of Frey and Boll, from blackberry, distinct from *T. malifoliella;* he regards as belonging to this species the specimens bred from all the species of Rubus, Cratægus, and Pyrus. He also doubts the distinctness of *T. roseticola.* However, in a later publication, "Tineina and Their Food Plants," Mr. Clemens recognizes the two species of Frey and Boll above cited, and as food plants of *T. malifoliella* gives Cratægus, *Pyrus coronaria*, and *Pyrus malus*, omitting as food plants species of Prunus, Rubus, and Rosa, assigning the two latter as food plants of *ænea* and *roseticola*, respectively. The distinctness of the three species was again recognized by Chambers in his Index to the Tineina of the United States and Canada, and more recently by Doctor Dyar in his "List of N. A. Lepidoptera."[a]

Finally Mr. Pettit notes serious damage to blackberries from *T. malifoliella* at the South Haven substation in Michigan, and states that the insects seem to breed in the neighboring apple trees and come to the blackberries from them. However, in the absence of definite breeding work and the critical comparison of adults thus secured, it will be best to follow the evident conclusions of Chambers and Dyar, and limit the food plants of *T. malifoliella* to species of Cratægus and Pyrus. During the present season (1907) the insect

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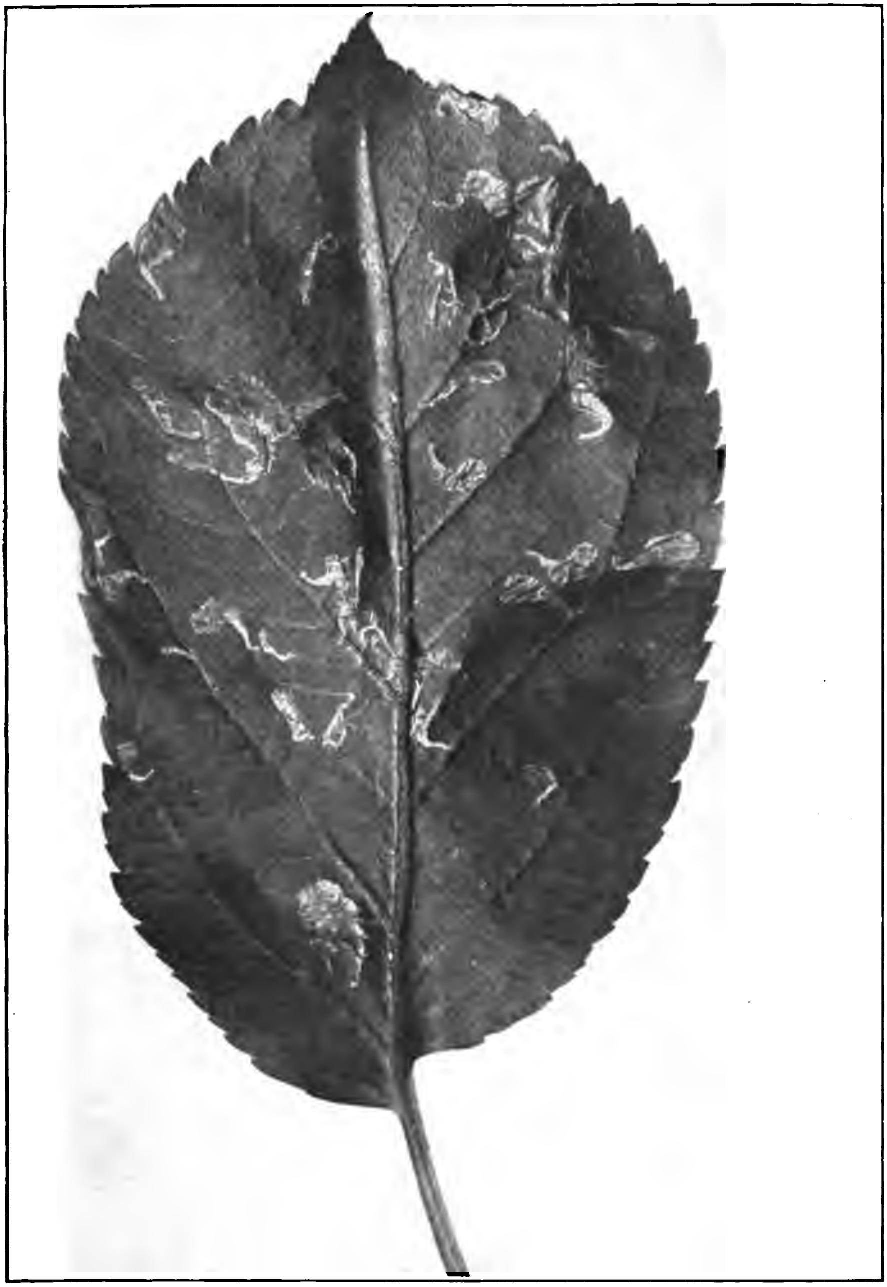
[a] Bul. 52, U. S. Nat. Museum, 1902.



WORK OF THE TRUMPET LEAF-MINER OF THE APPLE (TISCHERIA MALIFOLIELLA): LARVAL MINES IN APPLE LEAF.

was never found on blackberry, though growing in abundance near infested apple trees.

SEASONAL HISTORY.

But little of a definite character has been recorded concerning the seasonal history of this species. Clemens states that "when pupation begins the leaf is thrown into a fold, which is carpeted with silk, and the pupa lies within it. This state begins about the latter part of September, and the imago appears early in May." Brunn, who studied the species at Ithaca, N. Y., says, referring to the mines, "Within these clean and comfortable quarters the larva passes the winter." The observations of Weed, reported in "Injurious and Other Insects of Illinois" (1886), agree entirely with those of Brunn; and Lintner, writing in 1895, says it hibernates within the leaf in its larval stage. Pettit, in 1900, states that "The larvæ are said to change to the pupal condition during September, and to remain in that condition until the following May," and again, in 1904, he says, "The pupal stage is passed in the mines of the leaves, necessarily on the ground in the winter time." Observations of Lowe in 1900 at Geneva, N. Y., agree with those of Brunn and Weed, though on October 29 a larva was found evidently about to pupate.

Until 1900 this species was evidently considered single brooded, though no definite observations seem to have been made on this point. During that year Pettit reported for Michigan that full-grown larvæ were found about the middle of July and again September 16, indicating at least two generations of larvæ. August 16, 1905, in Niagara County, N. Y., the writer found numerous empty mines with protruded pupa cases, and a single live pupa in a mine. Young larvæ from eight to ten days old were fairly common, indicating a second generation for that section.

The abundance of the insects in the vicinity of Washington during the past two years has permitted some observations on this point. In 1905 the insect was first noticed, May 30, on an isolated apple tree near the writer's home in Kalorama Heights, D. C., and this tree has been kept under observation during the seasons of 1905 and 1906. On May 30, 1905, when first seen, the first generation of larvæ was maturing, one pupa being found, and by June 18 the great majority of larvæ had pupated, and quite 25 per cent of the moths had already emerged. The first generation of larvæ was quite abundant, almost every leaf having 8 to 10 mines. Practically all pupæ had yielded moths by June 30, and the leaves were peppered with eggs, many of which had already hatched, the larvæ being yet quite small, in linear mines. By July 27 the second generation of larvæ had mostly pupated and many moths were out and ovipositing.

The number of mines per leaf at this time averaged from 15 to 18. By August 4 pupæ had largely yielded moths, and eggs were again very abundant, a few having already hatched. By August 26 another generation of moths had developed and their eggs were in an advanced condition of development and many had already hatched. September 10 larvæ of this, the fourth generation, were of various sizes, from quite small to full-grown, but no pupæ could be found. The leaves, although practically covered with the mines on their upper surfaces, were still hanging on the trees, and there was but little evidence of serious injury having been done. By October 30 quite 50 per cent of the foliage was on the ground and those leaves remaining on the trees were more or less rolled in from the edges. This premature falling of the foliage was undoubtedly due to the work of the leaf-miner, and this seems to have been its principal injury. At this time the larvæ were full-grown and had lined their mines with a dense lining of silvery-white silk preparatory to hibernation. Leaves picked from the ground contained from 6 to 15 larvæ per leaf. Leaves examined December 6 showed no change of condition, no pupæ whatever being found, and this condition was also found to obtain on January 21. March 12 a quantity of leaves were collected from the ground, and at this time fully 90 per cent of the larvæ had transformed to pupæ, though this stage had but recently been entered, as indicated by the bright-green color. On April 22. at which time the foliage of the apple was just pushing out, only pupæ could be found, and some of these were quite dark in color, the inclosed moth evidently being nearly developed and ready to escape. The formation of pupæ as just mentioned is perhaps to be regarded as abnormally early, since the weather about this time was unusually warm. This belief is strengthened by the fact that in infested apple leaves kept in a breeding cage out of doors in the insectary yard the insects were all in the larval condition, except one pupa, on April 5, the moths mostly emerging the latter part of that month. By May 7 eggs were very abundant on the foliage of the apple tree under observation, as many as 12 being counted on a single leaf, but on some leaves none at all were to be seen. At this date no larvæ had yet hatched, though many eggs were in an advanced stage of development, the embryo being readily seen within the delicate shell when examined with a hand lens. By June 24 larvæ from these eggs had mostly matured and had entered the pupal stage, though a few full-grown larvæ were still to be found. The time of maturing of the first generation in 1906, therefore, agrees closely with this period in 1905.

Length of life cycle.—Eggs deposited during the night of July 31 were very generally hatching on the morning of August 8. The larva leaves the egg by eating directly through the lower surface at one end into the leaf beneath, at once beginning its mine, and is thus at no time exposed. The act of leaving the egg is very deliberate, and may occupy ten or twelve hours before the body is completely out of the shell and into the mine. Feeding alternates with resting, the larva often working backwards out of the mine into the eggshell, where it may rest for half an hour or more. The mines are at first but little wider than the width of the insect and are lined with silk from the start. Progress at first is slow, the larva proceeding about twice its length during the twenty-four hours following the breaking of the eggshell. After a few days, however, it feeds much more vigorously and soon widens the mine in the course of its feeding.

Of the larvæ which hatched the morning of August 8, 12 out of the 15 under observation pupated during the night of August 25, this stage therefore lasting approximately eighteen days; and the moths from these pupæ mostly emerged by the morning of September 2, one emerging the morning of August 30, making for the life cycle about thirty-three days. Moths kept in confinement without food lived for about two days. According to Chambers, the larvæ molt five times, and there are no marked differences either in color or structure between the larvæ at different stages of growth.

DISTRIBUTION.

The trumpet leaf-miner is evidently a native species, its original food plants probably being species of Cratægus and wild Pyrus. It has been recorded from New York, Texas, Illinois, and Michigan. The material on which Clemens based his description was probably from Pennsylvania, and the observations of Chambers made in Kentucky indicate its occurrence in that State. Records of this Bureau show it to occur in South Carolina, Virginia, Delaware, Pennsylvania, Connecticut, Rhode Island, Vermont, Massachusetts, Missouri, Arkansas, and Nebraska, and at Ottawa, Canada.

PARASITES.

This miner is freely parasitized. At Ithaca, Dr. Brunn bred from it *Sympiesis lithocolletidis* How. and *Astichus tischeriæ* How. The former species has been bred from this insect at Champaign, Ill., by Weed, and *Elasmus pullatus* Howard is doubtfully recorded from this species from Missouri. At different times during the season of 1905, at Washington, D. C., infested apple leaves were placed in jars, and the following species were secured, some of which probably are secondary parasites: *Urogaster tischeriæ* Ashm., *Sympiesis nigrofemora* Ashm., *Horismenus popenoei* Ashm., *Clasterocerus trifasciata* Westw., *Eulophus* n. sp., *Zagromosoma multilineata* Ashm., and a variety of this species. A species near Phygadeon was reared, and one near, if not identical with, *Cirrospilus flavicintus* Riley.

TREATMENT.

When excessively abundant, as has been the case in several localities during the past two or three years, the injury done by the larvæ in the leaves will cause many of these to fall prematurely, interfering with the proper development of the fruit and the health of the tree, and its control, therefore, becomes a matter of importance. This can perhaps best be accomplished by plowing the orchard in the spring, covering as much as possible all fallen leaves and trash, as in the former the larvæ pass the winter, and it is practically certain that the moths will not be able to make their escape from the soil. This work should be done not later than the blooming period of the trees, to insure covering up the infested leaves before any early-emerging moths escape. As this method of control involves no extra labor not requisite in proper orchard treatment, this species, which has but recently attracted attention as a pest of the apple orchards, is not to be regarded as a serious pest of the apple in the sense that it will require independent treatment.

After the insect has become established in orchards, and its immediate control appears necessary, a thorough spraying of infested trees with 12 or 15 per cent kerosene emulsion made in the usual way would no doubt result in the destruction of the larvæ and pupæ in the mines in the leaves, and possibly also of the eggs scattered over the foliage. Such work, however, should be done on clear, bright days, to lessen as much as possible danger of injury to the foliage from the spray. Tests of a kerosene lime emulsion alone, and with Bordeaux mixture and Paris green, have been reported by Prof. C. P. Close, formerly of the Delaware College Agricultural Experiment Station, in Bulletin 73 of that institution. In the experience of Professor Close, applications in early August of 10 and 15 per cent kerosene lime emulsions, with Bordeaux mixture and Paris green, were quite effective in killing larvæ and pupæ in the leaves. Applications of kerosene lime emulsions in September on the succeeding brood were not so successful in killing the insects, and the apple foliage was injured, possibly on account of its weakened condition following the work of the miners.

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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN No. 68, Part IV
L. O. HOWARD, Entomologist and Chief of Bureau.

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE LESSER PEACH BORER.

BY

A. A. GIRAULT,
Engaged in Deciduous Fruit Insect Investigations.

ISSUED OCTOBER 17, 1907.

WASHINGTON:
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1907.

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TEXT FIGURE.

FIG. 10. The lesser peach borer (*Synanthedon pictipes*): Adult, eggs, larva, pupa, cocoon, and pupal skin 35

U. S. D. A., B. E. Bul. 68, Part IV. D. F. I. I., October 17, 1907.

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE LESSER PEACH BORER.

(*Synanthedon pictipes* G. & R.)

By A. A. Girault.
Engaged in Deciduous Fruit Insect Investigations.

INTRODUCTION.

Until recently the only lepidopterous borer of the peach known to be common and injurious in the East was the peach borer (*Sanninoidea exitiosa* Say), an insect well known to entomologists and fruit growers alike. About ten years ago—in 1896—however, another somewhat similar borer, the subject of this paper, now called the lesser peach borer, was mentioned by Webster as "the peach borer," and again, four years later, Smith recorded it as being sometimes found on the peach in New Jersey, though apparently it was not considered a pest of any importance. It was with some surprise that, in the investigation of the peach borer by this Bureau during the past two years, this insect was discovered to be very abundant on peach in Maryland and Georgia, and also to a less extent in western New York and adjacent portions of Canada, occurring especially in the trunks of old or diseased trees. At first the larva was confused with that of the peach borer, but dissimilarities in its habits soon led to its recognition, which was confirmed upon rearing adults. Aside from its being a practically unrecognized enemy of the peach, the insect is of interest from the fact that it has heretofore evidently been more or less confused with the true peach borer, to which the larva bears great resemblance in general appearance. In subsequent pages there is given as complete an account of the species as is possible at this date.

HISTORY.

Up to the year 1906 the species under consideration had not been treated as an insect of special economic importance. Previous to this time it had been known mostly as occurring on the plum and cherry, and it had not been sufficiently abundant to cause more than occasional record of the fact in the literature of economic entomology. For instance, it is not mentioned in the Catalogue of the Exhibit of Economic Entomology at the Lewis and Clark Centennial Exposition, Portland, Oreg., 1905, given in Bulletin No. 53 of this Bureau. It has been listed several times, however, as occurring on plums and cherries, and in the following cases had been mentioned especially in respect to its injury to these plants: Kellicott reported serious injury, in some instances, to plums in New York State in 1881, but Smith, nine years later (1890),[a] stated that it was rare in New Jersey. In 1892 Kellicott reported serious injury to cherries in Ohio. In 1899 Lugger thought the insect was increasing in Minnesota. Finally, in 1906, Quaintance reported it as very abundant in Georgia, causing material injury to peach trees.

ORIGINAL DESCRIPTION; SCIENTIFIC NAME.

The insect was first described as new to science in 1868 by Grote and Robinson, from adults captured in the "Atlantic district (Penna.)." It was given the specific name *pictipes* and placed in the genus Ægeria of Fabricius. In 1881 it was redescribed as new by Henry Edwards under the name of *Ægeria inusitata*, from specimens obtained in the White Mountains, New Hampshire, and at Andover, Mass. Twelve years later Beutenmüller (1893) established *inusitata* Hy. Edwards, as a synonym of *pictipes*. In the meantime Smith (1890) had removed the species *pictipes* to the genus Sesia of Fabricius, which removal was accepted later by Beutenmüller (1896, 1897) and Dyar (1902). Soon afterwards Holland (1903), finding that the name Sesia had been restricted to a genus of the Sphingidæ by Fabricius, applied to the genus Hübner's proposed name, Synanthedon, which seems to be the proper course in this case (p. 385). The insect's scientific name, therefore, is *Synanthedon pictipes* (Grote and Robinson).

COMMON NAMES.

Owing to the fact that the lesser peach borer feeds in the larval stage on a variety of trees it has become known by local or common names, depending on its most common or most important food plant in particular localities. It was first found on plum, and hence was first called, by Bailey in 1879, the plum-tree borer, which has since been the name oftenest applied to it. In 1896, as previously mentioned, Webster referred to it incidentally as "the peach borer;" and in 1906 it was designated by Starnes as "the wild-cherry borer." In the same year, however, because of its increasing abundance on the peach and apparent preference for this tree over others hitherto chosen, Quintance proposed for it the name of the lesser peach borer, in distinction from the better known peach borer *Sanninoidea exitiosa* Say. This name seems preferable to any of the others, and more logical, because the peach is the most important food plant which it attacks at the present time.

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[a] Dates in parentheses refer to the bibliography at the end of this paper.

FOOD PLANTS; CHARACTER AND EXTENT OF INJURY.

It has already been indicated that the lesser peach borer has more than one food plant, a habit usual with the members of the family to which it belongs. Bailey, in 1879, first found it on the cultivated plum. Two years later, in 1881, Kellicott found it attacking old plum trees at Buffalo, N. Y., and also wild cherries (*Prunus serotinus* and *P. pennsylvanicus*). In 1891 the same author stated that, in addition to its favorite food plant, it also attacked wild black and red cherries at Columbus, Ohio, and very probably would be found on the cultivated cherry. Again the following year (1892) he briefly states that it attacks both cultivated and wild cherry in the same locality of Ohio. In 1893 Webster reared the insect from the black-knot fungus, *Plowrightia morbosa*, on cherry and plum. Beutenmüller (1896), three years later, gave two additional food plants, juneberry (*Amelanchier canadensis*) and the beach plum (*Prunus maritima*). During the same year Webster (1896) recorded it on peach. Beutenmüller (1897) then added chestnut, and in 1899 Lugger added wild plum, making the following known food plants to date: Cultivated and wild plums and cherries, black-knot fungus on plum and cherry, juneberry, beach plum, chestnut, and peach.

Recent records of this Bureau show that this borer has a decided preference for peach. For instance, in Georgia where large plum and peach orchards are grown side by side, an examination of each kind of tree showed that it was common on the latter and scarce on the former. We have been unable to find it numerous on wild plum and cherry in that State, nor have additional food plants been found. In Maryland we have found the larva in a knotty growth on peach some 5 feet above the ground. Mr. W. F. Fiske, of this Bureau, reared adults from girdled chestnut trees (*Castanea dentata*), at Tryon, N. C., May 28, 1904.

The insect is evidently increasing on peach, and at present in certain localities causes costly and, in the case of individual trees, fatal injury. Bailey (1879) records a fatal attack on a plum tree in New York; and as an example of such concentrated attacks on individual trees in orchards mention may be made of the case of a nearly girdled 3-year-old Greensboro peach tree in Georgia, from the slender trunk of which were taken 14 pupæ, 1 larva in cocoon, and 28 larvæ of various sizes.

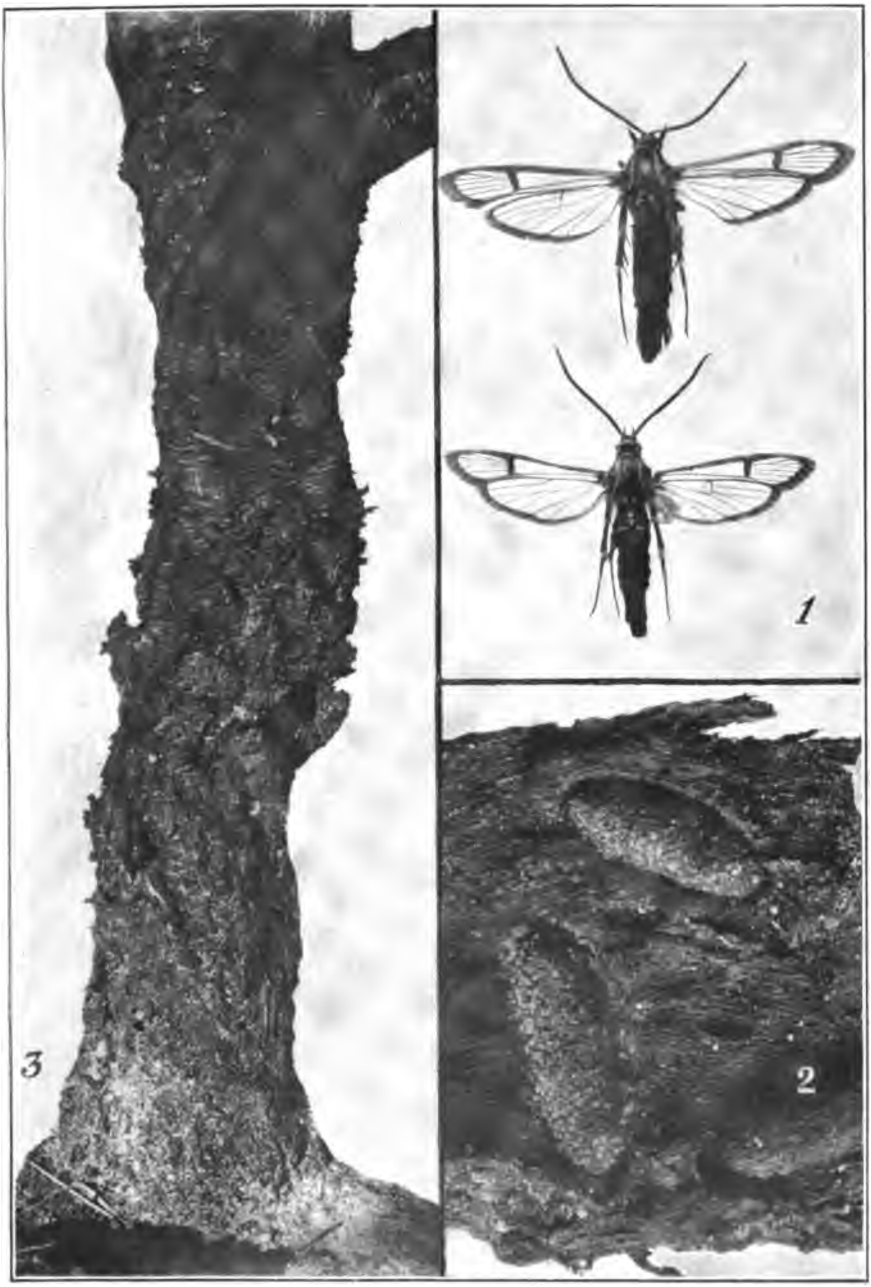
The attack of this insect is somewhat similar to that of the peach borer, but differs in many respects. Apparently it attacks none but injured trees, where the bark has been injured in various ways, and it is therefore usually found in old trees where this condition is more likely to occur (see Pl. VI, fig. 3). Further, the larvæ occur upon the trunk as a rule, make more irregular and longer burrows, and generally follow the outlines of wounds or along the edges of the cracked bark. They may be found, however, at or slightly below the surface of the soil and above the crotch or fork of the tree in the larger branches. The larvæ feed on the soft tissues of the living bark, and an infested tree exudes a considerable amount of gum from the area in which they are working. In some of the Georgia and Maryland peach orchards groups of old, scarred trees have been found with their trunks literally honeycombed by the channels of these larvæ, and this is likely to be the condition in any neglected orchard in which the trees have reached some size. An average of two larvæ to the tree was found in 14-year-old trees in Georgia in 1906, but occasionally individual trees were discovered harboring as many as 40 or 50 specimens of the insect in various stages.

DISTRIBUTION.

The lesser peach borer is rather widely distributed in the United States, to which it is native. In his List of North American Lepidoptera, Dyar (1902) simply gives "U. S.," denoting general distribution. Beutenmüller (1901), in his monograph of the Sesiidæ of America North of Mexico, gives from Canada to Florida and Texas, westward to the Pacific. It has been recorded from the following States: New York and adjacent portions of Canada, Pennsylvania, New Hampshire, Massachusetts, Illinois, New Jersey, Ohio, California, North Carolina, Minnesota, Maryland, District of Columbia, Virginia, and Georgia. It has been recorded as common and locally injurious in New York State and Ohio. The records of this Bureau (Quaintance, 1906) report it common in Maryland, western New York and circumjacent territory, and in Georgia, where it is especially abundant. It is known to occur on peach in New Jersey, Ohio, New York, Virginia, Georgia, District of Columbia, and Maryland.

LITERATURE.

The literature of this insect is not extensive. Bailey (1879) gives the only account of its life history yet published, and his description



LESSER PEACH BORER (SYNANTHEDON PICTIPES).

Fig. 1, Male and female moths (male above); fig. 2, cocoons as exposed by removing bark from trunk of peach tree; fig. 3, trunk of 10-year-old peach tree badly infested with the larvæ. Figs. 1 and 2, enlarged twice; fig. 3, much reduced. (Figs. 2 and 3, original; fig. 1, from Quaintance.)

of the character of injury is especially good. From time to time it has been treated systematically and figured, or listed, and for such treatment reference should be made to the bibliography given at the close of this article.

LIFE HISTORY AND HABITS.

The winter is passed in various stages of larval development under the bark of the trunks of the trees. Upon the approach of warm weather, and during warm spells in the winter in the South, the larvæ feed, and as they reach full growth construct cocoons and pupate (in March and April in Georgia and Maryland, respectively). About a month afterwards the moths begin to emerge and mate, and the females at once commence to deposit their eggs along the tree trunks. On account of the unequal development of the hibernating larvæ, the period of pupation and subsequent emergence of the adults lasts for several months. The eggs hatch after about ten days, and the young larvæ enter the bark through crevices and begin to feed. In Georgia, in the course of several months, these larvæ reach full growth and pupate, and the resulting moths establish another generation in the early fall, which hibernates as larvæ. The two generations are considerably mixed.

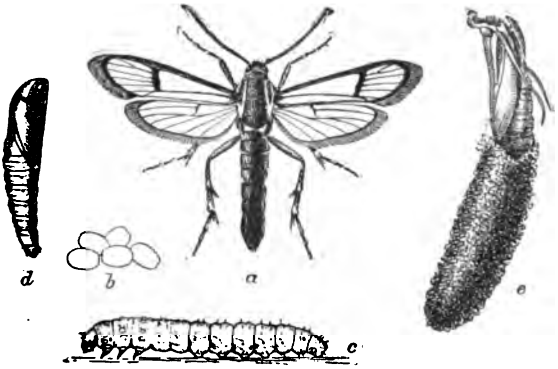


FIG. 10.—The lesser peach borer (*Synanthedon pictipes*): *a*, Adult; *b*, outline of eggs; *c*, larva; *d*, pupa; *e*, cocoon and pupal skin. (Original.)

The seasonal history of this borer is therefore very unlike that of the peach borer. It differs markedly in the fact of a partial second generation, and the further fact of early spring pupation.

The egg.—The egg (fig. 10, *b*) is a small, compressed, elliptical-oval, reddish-brown object, similar in general to the eggs of the peach borer and other members of the family Ægeriidæ. It harmonizes in color with the bark of the trees upon which it is deposited, and on this account is difficult to find. Seen from the side the anterior end is truncate, but viewed from in front it is found to be concave, the micropyle situated in the center of the concavity. The upper side of the egg, as seen when in position on a tree, is compressed and concave, the hollow being oval and following the outline of the margins; the bottom side or base is flat. The surface is rough and sculptured into irregular polygons with from three to six sides. The eggs are adhesive, hard, visible to the naked eye, but minute, measuring 0.63 by 0.38 mm., and are deposited singly. They differ in aspect from those of the peach borer, and also are usually lighter in color and not as large and stout. They are rather more difficult to find in nature.

At present the length of the period of incubation is not well known. Mr. Quaintance records it as 7½ days in the month of September, latitude of Washington, D. C. Upon hatching, the little larva cuts its way through the anterior end of the egg, leaving quite a large exit hole in the egg shell, which retains its shape and place until it weathers off.

The eggs were first observed in nature by Bailey (1879); he found a cluster of them on the under surface of loosened plum bark, about 6 inches above the roots. Usually, however, they are deposited singly along the trunk of the tree, being placed in crevices, openings, or roughened places. Sometimes a few are placed on the ground or high up in the tree on twigs or leaves, but the majority are deposited on the main trunk of the trees. The number deposited by a single female is unknown. Moths kept in confinement refuse to mate, and the female deposits few eggs or none at all. To determine the number resort is therefore made to dissection. Mr. Quaintance dissected two fertile females after death, and found 305 perfect eggs in one and 296 in the other, in addition to numbers of small undeveloped ones. Each moth had deposited a few eggs before dying, which were included in the count. Dissection of the ovaries of a sterile moth yielded but 58 perfect eggs, but there were present many undeveloped ones. Until more dissections are made the evidence on this point remains inconclusive.

The larva.—When the larva hatches it is very small, and especially hard to detect with the naked eye because of its dull white color. It is an ordinary caterpillar, bearing the usual setæ and number of prolegs, and in its earlier stages is almost indistinguishable from the young larvæ of the peach borer. However, after molting once or twice it acquires a different aspect, which together with a more pinkish and translucent color makes it somewhat more distinct. Throughout all its life it remains about the same color—various shades of creamy white—and lives concealed under the bark. The following is a description of a full-grown larva, or instar VI:

Length, 20.5 mm., average. Greatest width, 3.4 mm. Width of head, 1.94 mm., average. Normal for the family: Body soiled cream color, immaculate, with the usual more or less generalized characters. Head yellowish brown, darker at base of clypeus and on labrum and mandibles, and blackish at the lower outer angles of the paraclypeal pieces, edges of clypeus, and tips of the mandibles; pale at vertical triangle, outer edges of paraclypeal pieces, gular surfaces, epistoma, palpi, and antennæ, the last two somewhat darkened; mandibles broad and short, indistinctly five-toothed, the two inner teeth mere serrations, the third tooth short, truncate, and broad, one-half shorter than the second, which is shorter and broader than the first, which is also obtuse; cutting edge of mandible oblique; two setæ present, arising together from middle of inner edge. Clypeus long, acutely triangular, its lateral margins sinuate, not distinctly truncate at basal corners, which are impressed and bear two setæ, one caudad of the other; paraclypeal pieces long, narrowed centrally, including the clypeus; on the inner side of each paraclypeal piece near the posterior end is a slight depression from which arises a small seta, near the apex of the clypeus. Ocelli 6, weak, pale, the first four in a quadrangle, each with a distinct lateral pigment spot; the fifth more cephalad, ventro-laterad of antenna, also with pigmentation; the sixth smaller, caudo-laterad of the fifth, and without pigmentation; the group protected by setæ.

Cervical shield pale yellow, bearing twelve setæ, in two groups of three each on each side of meson, all separated, and the caudal one of the first group separated by a suture; laterad of the shield, cephalad of spiracle, a group of three from a calloused tubercle, of which the cephalic two are much the longer; directly laterad a group of two from a fleshy elongate tubercle, the caudal seta the larger; between these setigerous tubercles, caudad and opposite the spiracle, is a narrow nonsetigerous tubercle, much narrower than the second setigerous one (one next to the fore leg); spiracle oval, brownish; "vii" and "viii" small, on the venter (?) and base of fore leg. On segments II and III, i in the dorsal region consisting of two setæ, the laterad larger; ii the same, slightly advanced, dorso-lateral aspect; iii single, minute, caudad between ii and iv, nearer the latter; iv single, large, in a line laterad with iii, advanced slightly beyond i, and in the stigmatal line; v small, its setæ larger than iii, single, much advanced, cephalo-laterad of iv; vi some distance caudo-laterad of v, about in a line transversely with i, single, equal to iv, above base of leg; all in the second annulet. A calloused spot behind iii, and a smaller one above vi, some distance caudad of v. Segment IV, single, i cephalad, small, in first annulet; ii larger, caudo-laterad of i; i and ii from dorsal aspect, forming a trapezoid; iii some distance from i in a transverse line, equal to ii, apparently in the first annulet, just above spiracle; iv and v combined just below the spiracle, the seta of v larger; vi caudad, nearer to vii than to iv and v; vii consisting of two setæ in the ventro-lateral line, and viii of one seta in the ventral region, minute; a minute calloused spot behind iv and v. Segment V, the same, vii consisting of three setæ, one of which may be obsolete. Segments VI, VII, VIII, and IX, the same; vii, three setæ on cephalo-lateral aspect at the base of proleg; viii, minute and single, inner side base of proleg; the intermediate seta of vii longest. On segment X, ii caudad of i, vii consisting of two setæ, the inner the larger, vi nearer to vii. Segment XI, i and ii closer, the latter also closer together transversely, iii cephalo-mesad of the spiracle; iv small, against, and cephalad of the spiracle; vii a single seta. Segment XII, i apparently absent; ii, iii, and iv in a transverse line, iii and iv combined; v minute, between iv and vi, slightly cephalo-laterad of iv; vi large, cephalad; vii and viii single. Anal shield subobsolete, pale, bearing four large setæ on each side, minutely maculate. Segment XIII, four minute tubercles across the venter (vii and viii ?), in front of each proleg, and just below the shield, a line of five on each side of the segment, of unequal size.

Spiracle oval, inconspicuous, brown; that of segment XI larger, somewhat obliqued, and farther dorsad. The crotchets of the legs are variable in number, often unsymmetrical, and generally arranged as follows:

Proleg.	*Anterior row.*	*Posterior row.*
1.	14–18	12–14
2.	14–17	12–15
3.	14	12
4.	12	11
Anal.	8	0

For the first four prolegs, the crotchets vary from 11 to 18 in number; for the anal proleg they vary from 8 to 9. There are generally more present than in *Sanninoidea exitiosa* (see fig. 10, *c*).

As compared technically with the full-grown larva of the peach borer, the latter is 34 mm. long, 6 mm. in greatest width, with the width of the head at least 3 mm. The head of *S. exitiosa* is slightly darker in color, with a distinct, though variable, subtriangular pale area on each epicranial lobe, where they join below the vertical triangle; the mandible is relatively more robust, darker at the teeth, four of the latter distinct, the second tooth longest and more slender, the outer next in length, the third one-third shorter than the second, and obtusely rounded, the fourth a distinct tooth, but abruptly shorter, approaching the fifth, which is a mere serration; the two mandibular setæ are larger. The lateral margins of the clypeus are straight, each one changing angle at its basal third, making the clypeus shaped like △, instead of triangular; the basal corners of it are truncate.. The parclypeal pieces are generally straight, but curving basally to follow the margins of the clypeus; they are uniform in width. The first two ocelli and the sixth are practically pigmentless. The shields are darker yellowish. The arrangement of the tubercles is the same, but they are relatively larger, as are also the accessory warts and the setæ. There is a less number of crotchets in the prolegs, ranging from 8 to 16, and in the anal proleg from 5 to 8.

Though these technical differences exist, they can not be recognized in all points without considerable study, and an examination of a series of larvæ. The most conspicuous difference is the greater size of the larva of *Sanninoidea exitiosa* and its different aspect.

During the course of its growth the larva molts several times, each casting of the skin marking the end of a separate period of larval development called an instar. There is no direct evidence by rearing to show how many of these instars there are, but it has been shown that the heads of lepidopterous larvæ are of certain limited sizes in each instar, and therefore by measurements of a large series of the heads of these larvæ, the conclusion is reached that there are six, as shown in Table I. The larva molts five times. The length of the separate instars has not been determined, but Mr. Quaintance records a little over seven months as the length of the larval stage for an individual reared on peach out of doors, from September to the following April, in the latitude of Washington, D. C.

TABLE I.—*Measurements of the head of the larva of Synanthedon pictipes in each of the six instars.*

	I.	II.	III.	IV.	V.	VI.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Average size	0.27	0.55	0.86	1.18	1.53	1.94
Range	([a])	([b])	0.72-0.95	1.02-1.25	1.36-1.70	1.84-2.64
Difference			0.23	0.23	0.34	0.80

[a] Constant. [b] Not obtained.

After hatching the young larva enters the tree by the way of a crevice and soon begins to feed on the soft living tissues. It grows rather rapidly and makes an irregular burrow between the living bark and wood of the tree. This channel, in time, becomes filled with semiliquid gummy exudations and the reddish frass of the larva. Where the larva enters there is left a small pile of fine reddish wood dust. It is partial to wounds or diseased areas on the trunk, but, as formerly stated, may occur anywhere on the tree, from the crown of the root to the larger branches, and thus may be found feeding side by side with the peach borer.

In confinement the larvæ will feed readily and grow on fresh pieces of peach bark; Mr. Quaintance has fed one for several days on peach leaves. When young, they are able to suspend themselves with silk, and Bailey (1879) has observed them "drinking" moisture.

After the larva attains full growth and is ready to pupate, if some distance from the edge of a wound or crack, it cuts a hole through, or nearly through, the outer bark, and constructs a cocoon under this in a suitable cavity, so that its anterior end is against the opening. If it is near the edge of ruptured bark, which is more commonly the case, the cocoon is made just within the boundary of the wounded area, so that the pupa easily pushes out when ready to issue as an adult. In old peach trees with cracked bark the cocoons are usually found in this position.

The cocoon is constructed of pieces of bark chewed into fine bits, frass, and silk secreted by the larva, and is light yellowish brown in color and soft to the touch. An old cocoon, however, is dark in color, and hard and brittle. The size of the cocoon varies, but it is always several millimeters longer than the pupa which it incloses.

The pupa.—The larva, having formed a cocoon and inclosed itself within, waits several days and then pupates. The pupa (fig. 10, *d*) is brownish yellow in color, darker at the edges of the segments, sutures, head and wing covers, spindle-shaped, and is broadest at the first abdominal segment. It has all the characters normal to its family. The setæ are sparse and minute. The spines on the first abdominal segment are very weak; in the female there is but a single row of these spines after the fifth abdominal segment, and in the male after the 6th abdominal segment. The secondary sexual characters are therefore distinct (Beutenmüller, 1901, p. 231). The cremaster consists of eight stout spines surrounding the anal end. Structurally the pupa is similar to that of the peach borer, but easily distinguished from it by its much smaller size and lighter color, by the smaller and lighter cocoons, and by the more finely granulated structure of the latter. The pupa varies considerably in length, being from 10-17 mm., averaging about 14 mm.

Just after formation the pupa is nearly white, gradually turning darker and becoming its normal color after some hours. As the instar approaches its close, it turns darker and darker, gradually assuming the color of the inclosed moth, becoming steel blue-black a day or so before emergence. Emergence, however, may be delayed several days after the assumption of this color. In the cocoon the pupa is naturally covered with more or less moisture.

The duration of the pupal instar varies according to season and latitude. At Myrtle, Ga., and vicinity records of actual instars obtained during 1906, from pupæ first formed, in the late winter and early spring, showed a maximum period of 32 days, and a minimum period, toward the end of April, of 20 days. In the latitude of Washington, D. C., records obtained in 1905 for first pupæ, formed in April, the adults emerging early in May, gave the actual pupal instar from 20 to 30 days. By the middle of May in the same latitude the period had decreased to from 15½ to 17 days, where it remained for the rest of the month. Mr. W. F. Fiske records the actual pupal instar at Tryon, N. C., as being about 26 days during May, 1904. These records do not include the several days spent in the cocoon as a larva, which must be added.

Immediately preceding the final ecdysis the pupa becomes restless and somewhat swollen, and, by aid of the rows of spines with which it is armed, rather quickly works its way through the anterior end of the cocoon up to about its fourth or fifth abdominal segment. The moth emerges while the pupa is in this position, projecting for more than half its length from the cocoon. (See fig. 10, *e*.)

The adult.—Moths of the lesser peach borer (fig. 10, *a*, and Pl. VI, fig. 1) resemble in general others of the family Ægeriidæ and more particularly the males of the peach borer. They may be distinguished most easily from the latter by the fact of their bearing but two yellow bands on the abdomen, on the second and fourth segments, respectively, the band on the fourth segment sometimes not entirely encircling it; whereas the male of the peach borer has a yellow band on the posterior margin of each of the abdominal segments, some of which may be more or less obsolete. The males of the latter are also larger than the moths of the former, but again agree in having a general hymenopteriform aspect, but flying in the bright sunlight the two species are easily recognized after a little practice in observing them. The sexes of the lesser peach borer are quite similar, but may be distinguished by one or two minor secondary characters, such as the simple antennæ of the female and the more robust abdomen and straight anal tuft. Probably the most available secondary character, however, is found in the frenulum, which in the female consists of two closely applied, long, and slender spines, while in the male it is single and slightly shorter. This character is concealed by the front wings.

The adults emerge from the pupæ in the morning hours, generally between 7.30 and 9.30, the males issuing slightly earlier than the females. They are more likely to issue on clear days, being somewhat retarded by cloudy or inclement weather. At the time of ecdysis the pupa, which is projecting from the cocoon as described, commences peristalsis-like movements of the abdominal segments, which after several seconds cause the pupal integument to part rapidly along the meson of the thorax and the sclerites of the head and wings. Almost simultaneously with this parting of the pupal integument, the moth begins to move forward and glides out, the forelegs holding to the nearest object to prevent it from falling. The actual emergence requires but a few seconds. At this time the moth is perfect but for folded wings, and can move with a peculiar jerky, gliding motion when it falls to the ground or is disturbed, but otherwise it prefers to remain motionless or to crawl to a convenient place. During the unfolding of the wings, when the moth is weak and delicate, it is probably in the most critical stage of its existence. If it falls, it is likely to injure the soft wings and become crippled, in which case it will almost certainly die a few hours later. The slightest injury at this period appears to be fatal directly or indirectly. The wings begin to swell at once and slowly expand, becoming normal after about 8 to 10 minutes. After expansion, however, they are still weak and unfit for use for at least another half hour.

As soon as ready for flight, the female moves to a convenient place and, taking position, begins to attract the males by elevating the end of the abdomen and extending the ovipositor horizontally from it. No perceptible odor is present. In badly infested orchards the males will begin to arrive after 3 or 4 minutes, or earlier, and soon a swarm of a dozen or more will be humming around the female. The sexes unite suddenly; the male grasps the female with the claspers, and then turning assumes the position normal to the Lepidoptera. Copulation may last a variable time. Mr. J. H. Beattie, then connected with this Bureau, observed a pair remain in copula for 65 minutes on August 16, 1905, at noon, and an observation made in the late summer of 1906 gave 58 minutes. In case the weather is unfavorable or no males appear, the females will continue to await them for several days, during the time from about 10 a. m. to 3 p. m.

Oviposition commences soon after copulation and continues throughout the life of the female. On warm sunny days it may begin as early as 8 o'clock in the morning, in the South, and continue at intervals through the day until as late as 4.30 p. m. On very windy or stormy days the female is inactive, hiding in the grass in the orchard for shelter, and on cloudy days she is less active than on clear ones. During the period of oviposition she flies very rapidly, and is hardly discernible until she alights on the trunk of a tree; she then moves slowly over the bark and feels with the end of the yellowish ovipositor for a rough place or crevice, where she usually places an egg. Ovipositing females are exceedingly difficult to follow with the eye, and in this respect they differ markedly from the comparatively sluggish and more conspicuous females of the peach borer. Further, they are apparently more careful in placing eggs, always selecting a place which will make it easier for the larva to get into the bark, though enough observations have not been made on this to justify a positive statement.

In flight both sexes resemble wasps and make a distinct buzzing sound. The males are seldom seen. The moths have never been observed to feed, except on moisture, and in confinement show no marked attraction to sweetened water. Meager observations made on adults kept in confinement indicate that they probably do not live longer than a week.

SEASONAL HISTORY.

GENERATIONS.

The number of generations occurring with an insect of this kind is especially difficult to determine because of the nature of its habits. In Georgia some attempt has been made by this Bureau during the past two years to obtain accurate knowledge on this point by keeping periodical record of specimens taken from a number of peach trees during the entire breeding season. So far, however, the data obtained do not warrant a definite or positive statement concerning the actual number occurring. They are, however, sufficient to indicate more or less clearly that a partial second generation during the breeding season does occur.

As previously stated, throughout the winter the larvæ may be found in all instars, excepting perhaps the first, so that recently hatched and nearly full-grown specimens are present, the former indicating late fall, the latter, late summer, oviposition. As soon as spring begins to open the old larvæ commence to pupate, emerging a month later as adults; the young larvæ feed and grow rapidly, pupating in their turn, and producing a continuous supply of moths. The moths from the hibernating larvæ produce another mixed generation of larvæ which reach full growth and begin to pupate and emerge as moths in the late summer and early fall. In turn these early fall adults oviposit, producing a mixed generation of larvæ throughout the fall of the year; these pass the winter and mature the following spring. Hence two cycles of this insect are clearly indicated during a calendar year in the latitude of Georgia. A clearer conception of the probable occurrence of these two generations may be obtained by consulting Table II.

TABLE II.—*Generations of the lesser peach borer at Myrtle, Ga., 1905–6.*

Generation No.	Larvæ.	Pupæ.	Moths out.	Approximate length of cycle.
1. Winter......	Sept. 10–May	Mar. 1–May 20 (Apr.).	Apr. 1–June 20 (May).	7½ months.
2. Summer	Apr. 10–Aug. 1 (May and June).	July 20–Oct. 15 (Sept.).	Aug. 15–Nov. 20 (Sept. and Oct.).	4½ months.

In Georgia, in 1906, the first pupa of what may be called the winter generation was found on February 27, and by the middle of March they were common. A month later, in April, the adults of that generation were common, continuing so throughout May and part of June. By the latter part of May the pupæ became scarce, showing that by this date the winter generation was practically over. From that date on we conclude that the larvæ then present in the trees were practically all of the next, or summer, generation. By the last week in July pupæ were again found in numbers, and continued to increase well into September, when adults of the summer generation were observed ovipositing. The winter generation, therefore, became established mainly in the latter part of August and during the whole of September, and the larvæ from eggs deposited then had ample time to obtain at least two months' steady growth before being disturbed by cold weather. The foregoing statement is based on series of specimens collected weekly throughout the entire season of 1906, from February to November, at Myrtle, Ga., by Mr. A. H. Rosenfeld and the author, combined with records obtained by Mr. James H. Beattie during the investigations in 1905 at Fort Valley, Ga.

Observations made in the vicinity of Odenton, Md., and Washington, D. C., show that the pupæ were present in the spring as early as the first week in April and that adults issued from these during the first half of May. The pupæ continued present as late as May 8, but thereafter we have no records. Mr. Fred Johnson, of this Bureau, records seeing adults at North East, Pa., on May 29; and at Niagara, Canada, June 23, 1905, Mr. Quaintance found larvæ nearly or quite full grown, and pupæ and adults were present. Bailey (1879) found the moths as early as May 25, in 1879, at Buffalo, N. Y., and made a general statement to the effect that they issue during June and July. Kellicott (1881) reports the same months for New York and Smith (1900) for New Jersey, and similar statements have been made by the various authors. For northern latitudes we are unable at present to form any definite conception as to the number of generations.

LENGTH OF THE LIFE CYCLE.

The length of the life cycle or developmental period of a generation of the lesser peach borer, based on field observations, has already been given in connection with Table II. The life cycle of the summer generation was approximately 4½ months, and of the winter generation 7½ months. Fortunately Mr. Quaintance has succeeded in actually rearing a single specimen of this insect through its entire cycle, in the grounds of the Insectary of this Bureau. On September 5, 1905, he placed 8 recently hatched larvæ in small artificial wounds made 3 feet from the ground on the trunk of a peach tree. Each larva was placed in a separate wound and the whole then protected by a wrapping of paper. By October 1, not quite a month later, 5 of the larvæ were found in their respective wounds and had grown remarkably, being from a half to five-eighths of an inch in length (13 to 16 mm.). On the 24th of the same month, or just over a month and a half after hatching, the five larvæ were still alive and were either about to molt or had just done so; three of them measured 13 mm., one 16 mm., and the fifth, 19 mm., averaging about 15 mm. The following spring, on April 5, 1906, another examination was made, and it was found that 4 of the larvæ had perished. The remaining one was inactive, but began to feed voraciously five days later, and by about April 13 had formed its cocoon and pupated. The moth, a male, emerged on May 14, 1906.

The lengths of the respective stages for this individual were as follows: Egg, 7½ days; combined larval instars, 220 days; pupal instar, 31 days; making a total of 258 days, or 8.6 months for the cycle (from August 28, 1905, to May 14, 1906). This agrees remarkably well with time approximated for the winter generation in the South, where the periods of larval inactivity during the cold months are naturally shorter, and hence growth is more rapid. The individual reared was a descendant of parents from Fort Valley, Ga., mailed to Washington.

NATURAL ENEMIES.

The lesser peach borer has a number of natural enemies, nearly all of which are parasites belonging to the order Hymenoptera.

Elachertus n. sp., of the family Eulophidæ, as determined by Mr. E. S. G. Titus, is probably the most common, and is an internal parasite which is fatal to the host just before pupation. After the host larva has constructed its cocoon the parasitic grubs eat their way through its body and pupate nakedly in the host cocoon, entirely filling it. As many as 138 of these parasites have been reared from a single larva of the lesser peach borer. It has been found at Odenton and Jessup, Md. (March to May, 1905), and at Fort Valley (April, May, July, 1905), and Myrtle, Ga. (March, 1906).

Bracon mellitor Say is also a rather common parasite of the lesser peach borer, and its method of attack is similar, being fatal to full-grown larvæ in their cocoons. After leaving the body of the host the parasite larvæ spin small compact cocoons side by side, which completely fill the host cocoon. They pass the winter in this condition and emerge the following spring. Thirty-four males and 31 females of this parasite were reared from two host larvæ during April, 1905. The parasite also attacks the larva of the peach borer and has a number of other hosts. It has been found to occur in the same localities as the eulophid parasite, but in Georgia, in 1906, it was rarely met with. It was rather common in Maryland in the spring of 1905. A species of Microbracon was also reared from the larva in Maryland and Georgia.

During 1905, at Fort Valley, Ga., Mr. J. H. Beattie, then of this Bureau, reared *Conura* n. sp. (determined by Titus), from the lesser peach borer. The parasite emerged May 30 from the pupa. Also in May he reared *Pimpla annulipes* Brullé, from the same stage of the host. This is probably the parasite referred to by Bailey (1879). Mr. Beattie also reared a species of Campoplex in May, 1905, and a species of Mesosternus in May and June, at Fort Valley, from this borer, making a total of six hymenopterous parasites, all of which were determined by Mr. Titus.

An undescribed variety of *Dorymyrmex pyramicus* Roger, as determined by Mr. Theodore Pergande, has been observed to attack the larva when exposed during "worming." This ant is very numerous in the peach orchards of Georgia, in the vicinity of Fort Valley, and will prey upon any insect which it is able to overcome. Ordinarily it is unable to get to this borer. Occasionally, however, it will kill recently emerged moths, and any larvæ which may have been overlooked during "worming," but which had been exposed. Mr. Titus reports this ant as being abundant on peach trees at Monticello, Ga., in August, 1905.

It is indicated that birds sometimes extract pupæ from cocoons under loose bark, and Bailey (1879) mentions a woodpecker as extracting larvæ from the trunk of a plum tree.

The value of the parasites of the lesser peach borer is greater than that of its predaceous enemies.

PREVENTIVES AND REMEDIES.

From the fact that this insect prefers to attack trees which have been injured or diseased, or are old, having wounded or checked bark, it is obvious that anything which will tend to mitigate or prevent these conditions will in turn largely prevent the borer's presence. Therefore proper orchard management, keeping the individual trees in a good, clean, and vigorous condition of health, avoidance of mechanical injury when cultivating, and prompt treatment of wounds made about the body of the tree, are the surest ways to keep the orchard free from this insect.

For its control in orchards already infested there is but one available remedy, namely, cutting the worms or larvæ out of their burrows. This is best done in conjunction with the regular "worming" for the peach borer, the operator taking care to examine all portions of the trees from the roots up to the large limbs above the fork. In doing this it will be necessary to cut away portions of the bark, and wounds so made should be promptly cleaned and treated with some protective antiseptic, as thick Bordeaux mixture or the lime-sulphur wash. All rough, cracked, or diseased areas should be cleaned out and similarly treated, whether they are infested or not, as they form points of entrance for the borers and are in other ways a menace to the life of the tree. The "worming" for this insect should be arranged for the early spring, if convenient, as wounds made at that time heal more readily, and, besides, the larvæ are then pupating in numbers and can be more easily gotten at.

So far as known, other remedial treatments in the shape of caustic or preventive washes are practically worthless in the control of the insect, and their application would be merely a waste of money.

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Original description; poor figure of male.

1879. BAILEY, JAMES S. The Natural History of *Ægeria pictipes* G. & R. <North American Entomologist, Buffalo, Vol. I, pp. 17–21, Pl. III.

General account of injury to a plum tree, with notes on seasonal history and habits; descriptions of stages and figures. (Plate not seen.)

1881. EDWARDS, HENRY. *Ægeria inusitata* n. sp. <Papilio, N. Y., Vol. I, pp. 201–202.

Description of *pictipes* as a new species from New Hampshire and Massachusetts, under the name *Ægeria inusitata*.

GROTE, AUGUSTUS RADCLIFFE. *Ægeria pictipes* G. & R. <Bul. No. 2, Vol. VI, Geol. & Geograph. Survey, U. S. Dept. Interior, Washington (author's edition), p. 257.

Few references. Notes that the sexes are much alike and tells how they differ from those of male peach borer.

Kellicott, D. S. *Ægeria pictipes* G. & R. <Canadian Ent., London, Ontario, Vol. XIII, p. 7.

Brief note. Common at Buffalo, N. Y., on old plums, doing grave injury in some instances. Also on cherry. At Hastings Center, N. Y., found on wild cherries. Adults in June and July.

Marten, John. *Ægeria pictipes*, G. & R. <10th Rept. State Ent. on Noxious and Beneficial Insects of State of Illinois. (5th Ann. Rep. Cyrus Thomas), Springfield, pp. 106, 109.

Under bark of plum. Brief description of larva and pupa.

1882. **Grote, Augustus Radcliffe.** *Ægeria pictipes* Grote & Robinson. <New check list of North American moths, p. 12.

Æ. pictipes and the synonymic *inusitata* Hy. Edwards are listed separately. (Not seen.)

1884. **Fernald, Charles H.** Stand. Natl. History (Kingsley), Boston, Vol. II, p. 464.

Mention; attacks plum trees and is similar in habits to the peach borer.

1889. **Weed, Clarence M.** Plum Tree Borer (*Ægeria pictipes*). <American Naturalist, Phila., Vol. XXIII, p. 1108, Pl. XLIII, fig. 7.

Review of Kellicott (1891). Figure.

1890. **Beutenmüller, William.** *Ægeria pictipes* G. & R. <Annals N. Y. Acad. Sciences, N. Y., Vol. V (1889–1891), p. 204.

Larva on plum; rare.

Smith, John Bernhard. *Sesia pictipes* Grt. & Rob. <Cat. of insects found in New Jersey. (Final Rep. State Geologist, Vol. II), Trenton, p. 289.

Mentions the species as generally distributed, but not common.

1891. **Kellicott, D. S.** The Plum Tree Borer (*Ægeria pictipes*). < Journal Columbus (Ohio) Hort. Soc., Vol. V (1890), pp. 16, 19, Pl. I, fig. 7.

Brief notes. Sexes similar and like male peach borer. Plum favorite food; plentiful on wild black and red cherry; probably on cultivated cherry. Larva mainly infests trunk and branches; abundant at Columbus. Recommends knife.

Smith, John Bernhard. List Lep. Boreal America, Phila., p. 20.

Listed as *Sesia pictipes* G. & R.

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Listed as type in Henry Edwards's collection. One male, Andover, Mass.

1892. **Kellicott, D. S.** Notes on the *Ægeriidæ* of Central Ohio. <Canadian Ent., London, Ontario. Vol. XXIV, p. 46.

Few lines. Quite abundant at Columbus, Ohio. Seriously injuring wild and cultivated cherry, as well as plum.

1893. **Beutenmüller, William.** *Ægeria pictipes* Grote & Robinson. <Bul. American Mus. Nat. Hist., N. Y., Vol. V, p. 25.

Establishes *inusitata* Hy. Edwards (1881) as a synonym of *pictipes*.

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Reared from the fungus on cherry and plum.

1896. **Beutenmüller, William.** *Sesia pictipes* (Hy. Edwards). <Bul. American Mus. Nat. Hist., N. Y., Vol. VIII, pp. 134–135.

Wrong author given. Synonymy; secondary sexual characters. Larva on plum, wild cherry, juneberry, beach plum. Canada, New Hampshire, Massachusetts, New York, New Jersey, Pennsylvania, Ohio, Illinois, and California.

Webster, Francis Marion. Bul. No. 68, Ohio Agric. Exp. Sta., Columbus, p. 25.

Mention as "the peach borer, *Sesia pictipes*."

1897. **Beutenmüller, William.** *Sesia pictipes* (G. & R.). <Bul. Amer. Mus. Nat. Hist., N. Y., Vol. IX, p. 220.

Larva under bark of plum, cherry, beach plum, chestnut, and juneberry, usually some distance up from base of tree; also on black knot fungus.

1898. **Lugger, Otto.** The Plum Tree Borer (*Sesia pictipes* G. & R.). <Bul. No. 61, Minnesota Agric. Exp. Sta., St. Paul, p. 119, fig. 63.

Same as Lugger, 1899.

1899. Idem. The Plum Tree Borer (*Sesia pictipes* G. & R.). <4th Ann. Rep. Ent. State Exp. Sta. Univ. Minnesota f. 1898, St. Paul, p. 65, fig. 63.

Short summary account. Apparently increasing. Larva feeds mainly in trunks and branches of wild and cultivated plums and cherries. Figure of adult. Recommends use of pruning knife.

1900. **Beutenmüller, William.** Synopsis of food-habits of the larvæ of the Sesiidæ. <Canadian Ent., London, Ontario. Vol. XXXII, pp. 301, 302.

Sesia larvæ sometimes found in borings made by other insects. Under bark of cherry, plum, and juneberry, some distance from base of tree, or in the limbs.

Smith, John Bernhard. *Sesia pictipes* (G. & R.). <Insects of New Jersey. Supplement 27th Ann. Rep. State Bd. Agric., 1899, Trenton, p. 472.

Listed from Newark, Staten Island, Philadelphia, etc. Adults in June and July. Larva on plum, cherry, beach plum, and sometimes peach, but rarely injurious.

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Systematic treatment, with synonymy, distribution, description, and food plants; colored figure of female. Moths out June and July. Time of adult emergence (p. 226), synoptic table of larvæ of the Sesiidæ (p. 229), and secondary sexual characters of pupæ (p. 231).

1902. **Dyar, Harrison Gray.** *Sesia pictipes* Grote & Robinson. <List of North American Lepidoptera. Bul. 52, U. S. Nat. Mus., Washington, p. 369.

Distribution given as "U. S."

1903. **Holland, W. J.** *Synanthedon pictipes* Grote & Robinson. <The Moth Book, N. Y., p. 386, Pl. XLVI, fig. 24.

Brief account. Synonymy and food plants. Adults on wing in June and July. Good colored figure of female.

Washburn, F. L. Plum Tree Borer. <Bul. No. 84, Minnesota Agric. Exp. Sta., St. Anthony Park, p. 82, fig. 70. Ibid., Eighth Ann. Rep. State Ent. Minnesota f. 1903.

Sesia. Listed as injurious to plums, with figure of male. Cut out and burn infested parts. Lugger's (1899) figure.

1905. **Kellogg, Vernon Lyman.** American Insects, N. Y., fig. 558 (p. 392).

Figures male. Sesia.

1906. **Beutenmüller, William.** *Sesia pictipes* Gr. & Rob. <Insects affecting park and woodland trees (Felt), Memoir No. 8, Vol. II, N. Y. State Museum, Albany, pp. 428, 453–454.

Brief account based mainly on Bailey (1879). Description of adults.

Quaintance, Altus Lacy. The Lesser Peach Borer (*Ægeria pictipes* G. & R.). Yearbk. U. S. Dept. Agric. f. 1905, Washington, p. 335, Pl. XXXI, figs. 3 and 4.

Brief account. Found abundant on old or diseased peach trees in Georgia and Maryland during 1905. Figures both sexes and pupal cast in cocoon. Recommends digging out.

Starnes, Hugh M. Bul. No. 73, Georgia Exp. Sta., p. 154.

Mentioned as the "wild cherry borer (*Synanthedon pictipes*)," and as being often mistaken for male peach borer.

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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY – BULLETIN No. 68, Part V.
L. O. HOWARD, Entomologist and Chief of Bureau.

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE LESSER APPLE WORM.

BY

A. L. QUAINTANCE,
In Charge of Deciduous Fruit Insect Investigations.

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PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE LESSER APPLE WORM.

(*Enarmonia prunivora* Walsh.)

By A. L. QUAINTANCE,
In charge of Deciduous Fruit Insect Investigations.

INTRODUCTION.

During the past three years the species known as *Enarmonia prunivora* has been found very commonly infesting the fruit of the apple in various parts of the United States, in some sections so abundantly as to cause serious loss to orchardists, the insect ranking in importance as an apple pest close to the codling moth.

The small, fusiform, flesh-colored larvæ, about three-eighths of an inch long, injure the fruit around the calyx by eating out shallow cavities or boring holes into the flesh from one-fourth to one-half inch or more in depth, in the ripening fruit occasionally penetrating to the seeds. The surface of the fruit, especially in the calyx basin, is also injured, the larvæ working beneath the skin and eating out galleries or large blotch mines, frequently with holes or borings extending more deeply into the flesh. The work of this species resembles rather closely that of the codling moth, and the similarity of the larva to the codling moth larva and a further similarity in the life histories and habits of the two species have doubtless been responsible for the almost complete oversight in the United States of this species as an important enemy of the apple.

HISTORY.

The lesser apple worm was discovered by Walsh in Illinois during July, 1867, in the course of a study of the plum curculio (*Conotrachelus nenuphar* Hbst.). Walsh found the larva in plum and about a month later bred out numerous moths from the same fruit. In the Prairie Farmer for December, 1867, page 359, under the caption "The plum moth," he makes brief reference to his discovery, and the same year, in the First Report of the State Entomologist of Illinois, page 78, presents figures and a full description, with interesting observations on its feeding habits, etc. He records having bred the moth the year previous from the "black-knot" of plum, from the cockscomb-like hollow gall (*ulmicola* Fitch) on the leaf of an elm, which is produced and inhabited by aphides, and also from a sessile hollow gall about the size and shape of a large pea or small cherry on the leaf of red oak (*Quercus rubra*) and described by Mr. Bassett as *Quercus singularis*.

The rearing of moths from larvæ in curculio-infested plums and "black-knot" and from elm and oak galls led Mr. Walsh to surmise that the larvæ did not infest sound plums and "black-knots," but followed the injury caused by the curculio, and in the elm and oak galls he believed the larvæ to be guests, it being uncertain whether they fed upon the tissues of the gall, upon the gall insects, or, in the case of the elm leaf gall, upon the sugary dust secreted by the aphides. Glover, in his report as Entomologist of the United States Department of Agriculture for 1867, page 73, briefly refers to Mr. Walsh's discovery, adding nothing, however, in the way of personal observations.

In Riley's First Missouri Report, page 65 (1869), brief reference is made to the plum moth in connection with a consideration of the plum-feeding habits of the codling moth, and again in the Third Report, page 6 (1871), it is mentioned as feeding on apples as they mature. Later in the same report (p. 25), under the caption "Two true parasites of the plum curculio," Doctor Riley points out Walsh's error in supposing that *Sigalphus curculionis* Fitch was not a parasite of the plum curculio, but of his plum moth, adding that this last insect had been bred by him from galls (*Quercus frondosa* Bassett), from haws, from crab apples, and abundantly from cultivated apples. In a footnote to an article on the codling moth in his Fifth Report, page 5 (1873), Riley comments further on this species as follows: "There is another and smaller worm, namely, the larva of what Mr. Walsh called the plum moth (*Semasia prunivora* Walsh), which is quite common on haws and apples. It does not penetrate deeply into the apple, but remains around the calyx and generally spins up there, and it so closely resembles the young apple worm that the two might be easily confounded." In the American Entomologist for 1880, page 131, in an article on parasites of the plum curculio, Doctor Riley quotes from his previous article on this subject in his Third Report, page 25.

The species is next mentioned in economic literature by James Fletcher in his report as Entomologist and Botanist to the Central Experimental Farm (Canada) for 1896, page 261, where he records that in Victoria, B. C., in 1895, specimens of a small caterpillar were found feeding on the surface of the fruit of the apple, particularly at the calyx end, eating the skin and mining a short distance beneath it. Similar larvæ were also received from Lachine Locks, Quebec, some of which, however, were working beneath the skin of the apple and producing large blotch mines. This is also probably the insect complained of by Mr. R. M. Palmer, in British Columbia, in a letter quoted by Fletcher in this same report. In his report for 1898, page 199, Fletcher again comments on this species to the effect that for many years the apple growers of British Columbia had noticed a small caterpillar answering in everything but size to the codling moth larva. The insect had been abundant, but the moth was not obtained until 1897, when a few were bred out by Mr. E. A. Carew-Gibson and forwarded by Doctor Fletcher to this Bureau, being determined here as identical with Walsh's plum moth. Fletcher records having bred this species at different times from apples and haws at Ottawa, from near Toronto, and from Lachine, Quebec. Single specimens had been received occasionally from Quebec and Ontario, but the insect had not been sufficiently abundant to attract attention. Fletcher's observations in British Columbia in the summer of 1897, and also observations by Messrs. Palmer and Carew-Gibson, led these gentlemen to fear that, from the numbers of the insect that were being found, the species might develop into a pest of importance. The great similarity of the injury of this insect to that done by the codling moth was noted, and also its general confusion by growers with this latter species. Later, in a letter to Doctor Fletcher, Mr. Carew-Gibson reported that the insect had been found through all the lower mainland and islands of British Columbia, usually attacking apples, but occurring also quite often in plums and prunes. In concluding his article Fletcher remarks that he considers it unlikely that this insect will ever develop into a serious pest of apples and plums, and regards its injury in British Columbia during the years mentioned as exceptional and due to the failure of wild crabs to produce fruit.

In Bulletin No. 61 of the Minnesota Agricultural Experiment Station, page 295 (1898), Lugger, under the caption "The apple bud moth," presents a brief note, stating that in addition to the apple this insect infests also the plum and cherry, and can become decidedly destructive by eating the buds of apple before they expand, causing in this way more injury than if the leaves were eaten. The larvæ are said to have the habit of feeding inside of cherries, thus causing them to drop.

In his report for 1900 Fletcher states, on the authority of R. M. Palmer, that this insect occurred in nearly all the fruit-growing districts of British Columbia except the Okanogan Valley, but in smaller numbers than in 1898–99.

Without question the larva of this insect is the one referred to by Mr. C. B. Simpson in Bulletin No. 41 of this Bureau, page 23 (1903), on the codling moth, under the heading "Unknown caterpillar working on outer surface of apples," and the work of which he well illustrated in figure 2 of Plate II. The injured apples were brought to the attention of the Bureau of Entomology by Mr. D. W. Coquillett, in October, 1901, the fruit having been purchased in the open market in Washington; it probably came from near-by orchards in Virginia or Maryland. In November, apples showing this same injury were found by Doctor Howard. A brief description of the larva is given by Simpson; none, however, was reared to the adult stage.

In Bulletin No. 22, new series, of the Division of Entomology, Chittenden, writing of "Insects and the weather; observations during the season of 1899," refers to the plum moth (*Grapholitha prunivora*) as having been quite abundant in some orchards, attacking and destroying both plums and apples.

Webster and Newell, in an article on "Insects of the year in Ohio in 1901" (Bulletin No. 31, new series, Division of Entomology, p. 89), record having bred *Grapholitha prunivora* from berries of a species of Cratægus. This species is again mentioned by Fletcher in his report for 1905, page 25 (1907).

Finally, Messrs. Sanderson, Headlee, and Brooks, in writing of the second brood of the codling moth (Bulletin 131, N. H. College Agric. Exp. Station, p. 25), mention the occurrence in late August of young larvæ, evidently just hatched, eating on the surface of the fruit. These small larvæ of the second brood feed "upon or just under the surface, often around or in the calyx, or where a leaf or another apple comes in contact with the skin, and rarely bore into the apple as does the first brood. Rarely do these worms of the second brood become full grown in this latitude, but late in September, when half grown, they form their winter cocoons. The difference in the food habits of this second brood has been observed by many growers and has led some to the belief that the work is that of a different insect." From the foregoing description of the work and habits of this larva, and from the figure presented of injured apples, it is possible that the insect in question is the species under consideration.

ORIGIN AND DISTRIBUTION.

The lesser apple worm[a] is doubtless a native insect, as indicated by its feeding on indigenous species of Cratægus, crab apples, and wild plums. The fact that it attacks cultivated plums and apples is not surprising in view of the close relationship of these wild and domestic fruits, and finds parallel in the case of numerous other American species which have become destructive to cultivated crops.

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[a] This name, first used by Fletcher for this species, is adopted in preference to Walsh's name, "plum moth," on account of the greater injury to apples.

In the literature of the species it has been recorded from the following States and Provinces: Illinois (Walsh); Missouri (Riley); British Columbia, Ontario, and Quebec (Fletcher); Minnesota (Lugger); Ohio (Webster and Newell); District of Columbia (Simpson and Chittenden), and New Hampshire (?) (Sanderson, Headlee, and Brooks). The insect has been bred by the Bureau of Entomology from fruit from the following places: Tazewell, Tenn.; Raleigh, N. C.; Macy, Ind.; Niagara-on-Lake, Canada; Youngstown, N. Y.; North East, Pa.; Baltimore, Riverdale, and Arundel, Md.; Pomona and Fort Valley, Ga.; Arlington, Afton, and Winchester, Va.; Nebraska City, Nebr.; Bentonville and Siloam Springs, Ark.; Garrison, Tex.; Ardmore, Ind. T.; Albert Lea, Minn.; Agricultural College, Mich; Tryon, N. C., and Gerrardstown, W. Va.

FOOD PLANTS AND DESTRUCTIVENESS.

Walsh bred this species from plum and "black-knot" and from elm and oak galls; Riley bred it from haws, crab apples, cultivated apples, and also from galls (*Quercus frondosa* Bassett). Fletcher records it from apples, haws, plums, and prunes, and Lugger states that it infests the apple, plum, and cherry, feeding on the buds of the apple before they expand and working within the fruit of the cherry. It has been noted by Chittenden as feeding on plum and apple, and on this latter fruit by Simpson and by Messrs. Sanderson, Headlee, and Brooks. Bureau of Entomology records show that this species has been bred from apple, *Cratægus* spp., peach, and plums—wild and cultivated. The larva of what proved to be this insect was also found during the summer of 1907 in the Ozark regions of Arkansas, boring down the terminal shoots of young, vigorous, growing apple trees, and also infesting "water sprouts" on older trees.

While the insect has frequently been bred from cultivated varieties of plums of the Japanese, Chickasaw, Americana, and Domestica types, including prunes, its injuries to these fruits have not thus far been observed to be very extensive. The larvæ feed upon the young plums early in the season, causing them to drop, and later bore into the maturing fruit. Their attack on apples, however, in some localities results in very important loss.

Injury to young apples by the first brood of larvæ may be quite extensive. Thus, in an investigation of the subject by the writer in apple orchards in the Ozark regions of Arkansas, from July 18 to 25, the past summer, this species was found to be quite as abundant as the codling moth; and this conclusion was reached also by Mr. E. L. Jenne, of this Bureau, who was stationed at Siloam Springs, Ark., for the season. At picking time the fruit from unsprayed trees in this region was quite as frequently injured by this species as by the codling moth, the two insects in unsprayed orchards injuring a large percentage of the crop. Almost equally serious injury from the lesser apple worm to fruit at time of harvesting was noted by the writer in orchards in the vicinity of Afton, Va., during the fall of 1905. Observations on this species by Mr. Fred Johnson, of this Bureau, at North East, Pa., during 1906, indicate that it is in that locality quite as abundant and destructive to apples as is the codling moth, attacking also Domestica varieties of plums. During the summer of 1906, in orchards in southeastern Nebraska, this insect was observed by Mr. Dudley Moulton, of this Bureau, and the writer to be everywhere abundant and destructive, and late in the season almost equally so with the codling moth.

Frequent examinations in the Washington markets of apples in barrels, coming mostly from orchards in Maryland, Virginia, and West Virginia, show often an injury by this species of from 15 to 20 per cent of the fruit, some of this occurring after the apples have been barreled, as proved by the presence of the larva. From these statements may be judged something of its present status and capabilities as an apple pest.

CHARACTER OF INJURY.

The great similarity of the injury to apples by this species with that of the larva of the codling moth and the similarity of the larva itself to an immature apple worm no doubt account for the fact that its considerable economic importance in the United States has been thus far overlooked. There are, however, certain differences in the character of injury of the two species, and in most cases the work of the lesser apple worm, in the absence of the insect itself, may be positively recognized. Injury by the first brood is perhaps confined more to the calyx end of the apple than later in the season. Cavities or holes from one-fourth to one-half inch deep are eaten into the flesh more or less around the calyx lobes and core within, the larvæ eating directly through the skin at the base of the sepals, or more commonly entering the calyx cavity, whence they bore out into the flesh and under the skin, this latter form of injury being quite easily overlooked. Very commonly, also, more or less winding, but eventually blotch mines are made under the skin in the calyx basin, often extending out to the sides; such mines also occur on the sides of the apples, especially where two are in contact or where an apple is touched by a leaf. Much of the fruit thus injured falls or ripens prematurely.

Later in the season the blossom-end injury is about as described, though there is a tendency on the part of the larva to penetrate deeper into the fruit, working in numerous cases observed quite to the seeds. The surface injury, however, is now rather more common, the larva eating out just under the skin large irregular, more or less winding or blotch mines, which are quite conspicuous. Under the

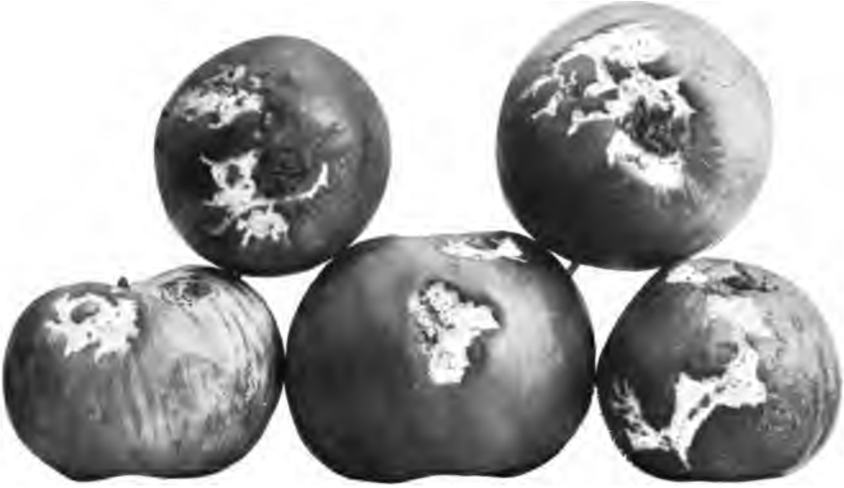

FIG. 1.—APPLES SHOWING SURFACE INJURY BY LESSER APPLE WORM (ENARMONIA PRUNIVORA). (FROM SIMPSON.)

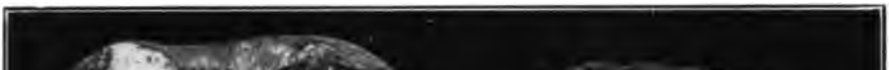

FIG. 2.—PORTIONS OF APPLES SHOWING WORK OF LESSER APPLE WORM (ENARMONIA PRUNIVORA).

In lower figures, injury at calyx and stem ends; in upper figures, injury to flesh under blotch mines. (Original.)

skin the larva as it grows may excavate cavities or holes extending into the flesh from one-fourth to one-half inch, or deeper. This surface injury, which may occur on the ends or sides, while perhaps not more serious in its effect than the borings at the calyx and stem ends, is more conspicuous and greatly disfigures the fruit. (See figs. 1 and 2, Pl. VII.)

Larvæ of this species apparently do not reach full development as early in the fall as those of the codling moth, and many find their way into the barrels, where they continue to feed, in some instances observed doing considerable damage, the introduction of the infested fruit being favored by the inconspicuous nature of the injury when occurring in the ends of the apples.

DESCRIPTION.

Egg.—The egg stage has not been observed.

Larva.—Full-grown larvæ (at time of leaving fruit in fall for hibernation) measure from 6 to 8 mm. in length. The body is somewhat fusiform, uniformly reddish flesh-colored above, lighter below, the intensity of coloring varying in different individuals from deep reddish pink or purplish to almost or entirely white. Head bilobed, retractile, brown to dark brown, in some specimens more or less mottled with dusky. The ocellar spots, a spot caudad on cheek, and tips of the well developed and strongly toothed mandibles, black; sutural lines dark brown to blackish; width 0.75 to 0.85 mm., and about as long as wide. Thoracic shield prominent, yellowish, transparent,

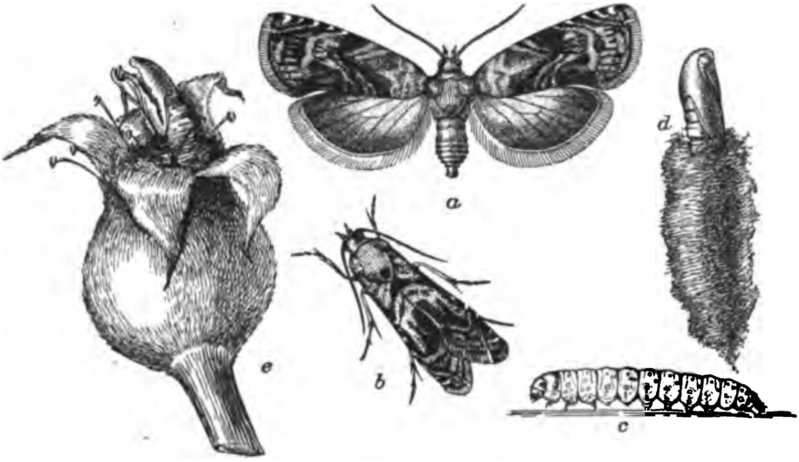

FIG. 11.—Lesser apple worm (*Enarmonia prunivora*) : *a*, Adult or moth; *b*, same, with wings folded; *c*, larva; *d*, pupa in cocoon, ready for transformation to adult; *e*, young apple, showing at calyx end empty pupa skin from which moth has emerged. Enlarged about three times. (Original.)

often with darker markings on caudal margin near median line. Anal plate brownish, with comblike structure on caudal curvature composed of from 5 to 7 closely set dark brown spines, the outer spine on each side considerably reduced. Spiracles small, dark brown; thoracic legs well developed, whitish, distal end dark, claw black. Abdominal prolegs well developed, each with a single circle of from 25 to 27 strongly curved, sickle-like hooks. Tubercular areas disk-like, whitish, with a single, slender, light-colored seta. On third abdominal segment: Tubercle I central, on dorso-lateral region; tubercle II caudo-ventrad of I, on posterior annulet; tubercle III about its width above spiracle; tubercles IV and V coalesced, directly below spiracle, about twice as far from it as is tubercle III, the seta of tubercle IV being considerably reduced; tubercle VI caudo-ventrad of IV and V, and tubercle VII with three setæ situated near base of proleg.[a] (See fig. 11, *c*.)

Cocoon.—About 6 mm. long and a third as wide. Exterior more or less covered with bits of bark or other material, concolorous with surroundings; within densely lined with whitish silk. (See fig. 11, *d*, *e*.)

Pupa.—About 5 mm. long. Color uniformly brown, except thoracic region, leg and wing sheaths, which, as pupa nears maturity, are darker. On dorsum of abdominal segments 3 to 7, between the spiracles on each side, are 2 rows of short, stout spines, projecting caudad, one row near cephalic border of segment and one near center or on caudal margin, the spines of caudal row smaller and more numerous. Remaining segments (except 1 and 2, which are spineless) with but a single row. Anal segment truncate, the 7 to 8 stout spines set on caudal margin. Cremaster of from 5 to 8 slender hairs hooked at tip and arising about equally distant from each other on caudal region of anal segment. Spiracles slightly elevated, dark brown. Wing sheaths and those of third pair of legs about equal in length and reaching middle of fourth abdominal segment. In emergence of adult, the pupa works out from cocoon about one-half its length, the empty exuvium remaining in this position in the cocoon. (See fig. 11, *d*, *e*.)

Adult or moth.—The description of the adult as given by Walsh in his first report as Illinois State entomologist, page 80, is herewith presented:

> Ground-color of front wing, black. The basal one-fourth irregularly covered with rust-red, so as to leave only a few black markings. On the costa, and rather more than one-third of the way to the apex of the wing, a pair of streaks obliquely directed toward the posterior angle of the wing; the inner streak of

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[a] The description of the larva by Simpson (Bulletin No. 41, Division of Entomology, p. 23) is not entirely in accord with the above. The length is said to be five-eighths inch, and for the "pre-spiracular" tubercle three setæ are recorded.

the pair is on its extreme costal end clear white, elsewhere pale steel blue, and extends nearly to the disk of the wing, where it almost unites with a subquadrangular pale steel-blue blotch, which is usually seen there without difficulty, though it is occasionally subobsolete; the outer streak of the pair is only half as long as the inner one, towards which it converges very slightly without actually uniting with it, and is colored in the same manner. Further along on the costa, and not quite two-thirds of the way to the apex of the wing, there is another such pair of streaks, parallel with the first pair and similarly colored, the inner one of which, when it has become as long as the inner one of the other pair, sweeps in a gradual curve round the disk of the wing till it almost attains the inner margin, a little way from its tip; while the other streak of the two is so very short that the steel-blue part of it is subobsolete and can only be seen in certain lights. Beyond this second pair of streaks, and rather more than three-fourths of the way along the costa to the apex of the wing, is another streak, parallel with all the others and similarly colored, which strikes the outer margin about one-third of the way from the apical to the posterior angle, where it terminates in a pale streak in the fringe. And beyond this again, and equidistant from it, from each other, and from the apex of the wing, there is on the costa a pair of short white streaks, the inner one much the shorter of the two. Thus along the costa we have a series of 7 very conspicuous short white streaks, arranged 2, 2, and 3. The terminal one-fourth of the front wing is mostly rust-red, with a series of abbreviated, black, longitudinal lines, springing from the other edge of the curved prolongation of the inner one of the second pair of streaks on the costa; and beyond these short black lines are two very oblique, short, pale steel-blue streaks, one springing from the posterior angle and the other a little above it from the outer margin. Disk of the front wing rust-red, with many indistinct, short, black, longitudinal lines, and on its center the pale steel-blue blotch already referred to. On the middle of the inner margin, a large elongate-triangular, rust-red patch, the apex of the triangle directed towards the apex of the wing and attaining the disk, the base of the triangle occupying nearly one-fourth of the inner margin. The triangular patch is bisected lengthwise by a very elongate and slender black triangle, the apex of which attains its apex; and the rust-red space on each side of this last triangle is again indistinctly bisected lengthwise by a still more elongate triangle composed of confluent black atoms. Fringe dusky, with a black basal line all along it. Hind wing dusky-gray at base, shading into black at tip. On the middle of the outer margin in the male, but not in the female, an elongate semioval patch (fig. 3*a*) of metallic brassy scales, brighter in certain lights. Fringe of the male (fig. 3*a*) long, sparse, and grayish-white on its anal half, short, dense, and dusky with a basal black line for its remaining half. Fringe of the female (fig. 3) nearly of uniform length, coarse and dusky throughout on the half next the wing, then suddenly fine and grayish-white on its outer half. Body brown-black. Face and palpi grayish-white. Shoulder-covers largely tipped with dull rust-red. Tips of the abdominal joints pale fuscous above. Legs dusky. All beneath, including the legs, with a more or less obvious silvery-white reflection. [See fig. 11, *a*, *b*.]

SEASONAL HISTORY AND HABITS.

Our knowledge of the life and habits of the lesser apple worm is still very incomplete, and it is hoped that numerous points may be cleared up during the course of another season. It is certain, however, that in several important respects the life habits are quite similar to those of the codling moth.

So far as observed, the winter is passed in the full grown larval condition. Cocoons are formed in cracks and crevices of the bark of apple trees, under bark scales, and probably wherever suitable protection may be found. Observations by Mr. S. W. Foster, of the Bureau of Entomology, October 21, 1907, in an orchard badly infested with this insect in the vicinity of Washington, revealed larvæ in cocoons in cracks in the bark and crevices, the small size of the larvæ enabling them to work into very small openings. In a breeding cage under out-of-door conditions, in the insectary yard at Washington, larvæ from fruit of Cratægus spun cocoons in cracks in the bark and under the bark scales of a portion of a limb of pear tree which had been introduced, and a few larvæ penetrated as deeply as possible in cracks in one end of the limb. The cocoons are made of bits of surrounding bark and are thus rendered difficult of detection; the interior is lined with whitish silk. First-brood larvæ often pupate in the calyx end of apples, or in plums, after these have fallen to the ground, and several instances have been observed where pupation has occurred in small, dry, and withered apples on the trees, and also in the fruit of Cratægus. In breeding cages larvæ have been observed to fold over flaps of apple leaves, making their cocoons in the protection thus formed. A few larvæ have been found under bands around apple trees, as used for capturing codling-moth larvæ, though not in sufficient numbers to indicate that the larvæ in summer go to the trunks of trees in numbers for pupation.

The overwintering larvæ pupate in the spring, the moths probably emerging about as is true for the codling moth. Observations by Mr. Fred Johnson, at North East, Pa., are to the effect that full-grown larvæ are abundant in apples during early July. At Siloam Springs, Ark., the past summer, Mr. E. L. Jenne secured moths June 20, 25, and 30, from apples collected May 31, and full-grown larvæ were found in apples that were collected at Afton, Va., June 26, 1907, the moths emerging July 12, and subsequently to August 21; also full-grown larvæ were found in apples sent in by Mr. L. M. Smith, Raleigh, N. C., June 8, 1907, and moths emerged June 28, July 1, and subsequently until the 23d. From apples from Pomona, Ga., received June 4, one moth emerged July 8. Apples collected at Winchester, Va., June 15, by Mr. S. W. Foster, gave adults July 3 and 9. Other breeding records for 1907 bear out those cited, though it should be noted that moths have been reared from fruit over practically the entire season, indicating an overlapping of generations perhaps more pronounced than is the case with the codling moth. However, in the Ozarks, in Arkansas, by July 18 to 25, 1907, 75 per cent of the fruit injured by this insect had already been deserted and the remaining larvæ were practically all full grown.

At Nebraska City, Nebr., during 1906, Mr. Dudley Moulton found full-grown larvæ in apples during late June and early July, moths issuing from July 6 to August 24, reaching their maximum, however, during late July and early August. The pupal stage was found to last from fourteen to sixteen days.

In 1905 full-grown larvæ were found in wild plums as early as April 28, at Fort Valley, Ga., and during the same spring mature larvæ were received in a sending of Japan plums from Garrison, Tex., by Prof. F. W. Mally, under date of May 20; and also in wild plums sent in by Mr. C. R. Jones, from Ardmore, Ind. T., a few days later.

At least two annual generations of larvæ are evident, though in the more northern States the second may prove to be only a partial one. Larvæ are notably later in leaving the fruit in the fall than is true of the codling moth, and are hence very commonly found at picking time, and it is likely that their occurrence has thus led to belief in an additional brood of the latter species, especially on the part of orchardists. Owing to their comparatively small size the larvæ may be readily overlooked, especially when in the calyx end, and infested fruit thus often goes into the barrels. In several instances which we have noted, important injury has been done by the larvæ to barreled fruit, the disfigurement of the surface being especially common.

IDENTITY.

The recorded feeding of this insect upon such diverse food as the "black-knot" of plums, elm and oak galls, and upon apples, plums, and Cratægus, naturally brings up the question of the identity of the insects secured from these several sources. On this point Walsh says:[a]

> Three specimens bred from Black-Knot Aug. 31–Sept. 7, three others bred from the Elm Gall (*Ulmicola* Fitch) July 24–Aug. 5, and a single one bred from Oak-Gall (*Q. singularis* Bassett) on Sept. 2, none of them differed from the plum-fed specimens in any important point. I sent a single specimen bred from the Black-Knot to the late Dr. B. Clemens about a year before his lamented death; but he never, so far as I know, investigated its classification. For the satisfaction of the incredulous I may add that I sent specimens bred respectively from the Plum and Elm Gall to the distinguished English entomologist, H. T. Stainton, who is well known to have made the smaller moths his special study for years; and that he agrees with me that they are perfectly "identical."

Also according to Stainton, as stated by Walsh, the species is most closely allied to the European *Semasia janthinana* Dup., which has also been bred from gall-like growths on hawthorn twigs. Riley also records breeding the species from galls (*Quercus frondosa* Bass.), in the Third Missouri Report, page 25. No further records of the insect occurring in galls or black-knot have been found by the writer, and we have not been able to breed it from these, in the limited trials thus far made.

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[a] First Report State Entomologist of Illinois, p. 81.

The moths which we have secured during the past three years from plum, apple, and Cratægus, and from terminal shoots of young apple trees, have been carefully compared by Mr. August Busck, of this Bureau, whose assistance we desire to acknowledge in this connection, and all have been found to belong to the same species, namely, *Enarmonia prunivora* Walsh.

PARASITES.

Only one hymenopterous parasite is recorded from this species, namely, *Mirax grapholithæ* Ashm., in apples from Washington, D. C., May 3, 1881. The insect which Walsh supposed was parasitic on this species, namely, *Sigalphus curculionis* Fitch, as shown by Riley is a parasite of the plum curculio (*Conotrachelus nenuphar* Hbst.), as has been known for many years.

METHOD OF CONTROL.

From the similarity in feeding habits of the lesser apple worm and the codling moth it would appear likely that proper spraying with arsenicals for the latter insect would also be effective in controlling to a considerable extent the former, and observations in orchards in Nebraska, the Ozarks, and Virginia show that this is the case.

The larvæ of the first generation, which mostly attack the fruit at the calyx end, are no doubt destroyed by the poison held in the calyx cavity, though, as has been noted, larvæ often bore into the fruit at the base of and outside of the calyx lobes. In some instances examined the calyx cavity and stony tissue of the core just under the skin have been left almost or quite intact. Feeding in this way larvæ would scarcely be poisoned. The comparatively small numbers taken from under bands of burlap around the trees, as used for the codling moth, show but little value from this procedure as used specifically against the lesser apple worm. Thorough spraying for the codling moth will perhaps best serve to keep the other pest in control, and where applications are made for the second brood of the former insect, these certainly will be of great use in reducing injury from the lesser apple worm late in the season.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 68, Part VI.

L. O. HOWARD, Entomologist and Chief of Bureau.

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

GRAPE ROOT-WORM INVESTIGATIONS IN 1907.

BY

FRED JOHNSON,

Engaged in Deciduous Fruit Insect Investigations.

ISSUED APRIL 24, 1908.

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INTRODUCTION.

For several years past the control of certain insect enemies of the grape has been a problem of increasing importance with the vineyardists of the Lake Erie valley. The insect causing most alarm is the grape root-worm (*Fidia viticida* Walsh). It was in 1899 that serious injury to the grape vine, which proved to be the work of this pest, was first noticed in the famous Chautauqua grape region, at Rip-ey, N. Y. For several years previous to the discovery of this insect n Chautauqua County, it had made serious inroads into the vineyards of the Ohio grape region, and was, in 1895, the subject of investigation by Prof. F. M. Webster, then entomologist of the Ohio Agricul-ural Experiment Station, to whom we are indebted for the first records of its complete life history and methods of control, a report of which was published in Bulletin No. 62 of the Ohio Agricultural Experiment Station.

Since 1900 this pest has been the subject of investigations in Chau-auqua County, by Dr. E. P. Felt, State entomologist of New York, nd Prof. M. V. Slingerland, of the Agricultural Experiment Station t Cornell University, both of whom made a life-history study of the insect and conducted field experiments in jarring and spraying the ines to reduce the number of beetles. The results obtained by these entlemen are embodied in Bulletins 59 and 72, New York State Mu-eum, by Dr. E. P. Felt, and in Bulletins 184, 208, and 224, of the Cornell University Agricultural Experiment Station, by Prof. M. V. lingerland. In Farmers' Bulletin No. 284, on Insects and Fungous Enemies of the Grape East of the Rocky Mountains, by Messrs. A. L. Quaintance and C. L. Shear, the grape root-worm is described, and its fe history and methods of control are briefly stated.

A BRIEF CONSIDERATION OF VINEYARD CONDITIONS.

During the past eight or ten years changes have occurred in both market conditions and in the age, area, and productivity of vineyards throughout the Lake Erie valley, which deserve brief consideration for full appreciation of the present active interest of vineyardists in this insect problem.

In 1900, when the grape root-worm first appeared in injurious numbers in the Lake Erie valley, the grape industry was just emerging from a period of depression which had caused, for several years previous, an almost complete cessation in planting of new vineyards. The period of low prices had resulted in indifferent care, amounting in some cases to positive neglect, thus creating a condition very favorable to the increase of this pest. The tendency of most vineyardists at that time was to pull out declining vineyards rather than to go to the expense of fighting insect foes. Furthermore, the fact that practically all vineyards had been for several years in bearing and had a well-established root system permitted the insect to become thoroughly disseminated through them before the unsuspecting owners were aware of its presence in numbers sufficient to affect the vigor of their vines. Thus it happened that a combination of circumstances conspired to favor a general spread of the insect without creating widespread alarm.

With the steady rise in the value of grapes since 1900, however, this condition has been reversed. Thousands of acres of new vineyards have been planted, and the more progressive vineyardists are commencing to appreciate fully what an enormous amount of injury has been done to their old vineyards, and are greatly alarmed at the rapidity with which many young vineyards are falling a prey to this pest.

A study of the production of grapes in the Lake Erie valley since the advent of the grape root-worm shows a steady decline in yield. The figures given below are taken from the "Chautauqua Grape Belt," a newspaper which is largely devoted to the grape interests of that region, and every year publishes carefully gathered statistics on grape production.

Grape crop production from 1900 to 1907.

	Carloads.
Yield for 1900	8,000
1901	6,689
1902	5,062
1903	2,954
1904	7,479
1905	5,965
1906	5,463
1907	5,186

The true significance of these figures, however, is not realized unless we take into consideration that there are now nearly 10,000 acres more of bearing vineyard than there were in 1900, which should of themselves produce nearly 1,800 carloads of fruit.

An analysis of the 1907 crop report brings out forcibly the deterioration of the old established vineyards. In the three townships of Portland, Westfield, and Ripley, in which there has been much less new planting than in the townships at either the eastern or western extremities of the grape belt, and which therefore come nearer to giving the true decline of old vineyards, there was a decrease of 585 carloads of grapes below the crop for 1906. Placing the value of grapes at $25 per ton, the lowest price paid for grapes in 1907, there was a shrinkage in value approaching $175,000 in these three townships. While some of this decline in production may be due to depletion of soil, lack of proper cultivation, and adverse weather conditions, yet many vineyardists who are careful observers are now convinced that a high percentage of this loss is due directly to the ravages of the grape root-worm.

It is a fact notorious to all vineyardists that wood production in nearly all vineyards has greatly decreased. In the issue of the "Chautauqua Grape Belt" for January 7, 1908, the statement is made, in predicting a light crop for 1908, that in most vineyards the wood growth is 65 per cent of the normal wood growth of several years ago, and in many vineyards is as low as 25 per cent. Extended observations during the past year convince the writer that this statement is by no means exaggerated.

It was because of the existence of such conditions as are described above that the vineyardists of North East, Pa., became alarmed for the future of their vineyards, and appealed to the Secretary of Agriculture for assistance. In compliance with this request investigations were commenced by the Bureau of Entomology in the spring of 1907.

WORK UNDERTAKEN AT NORTH EAST, PA.

The main features of the work against the grape root-worm at North East, Pa., during the past summer have been: (1) A close study of vineyard conditions to determine the amount of injury for which this insect is responsible, and the amount of injury done to vines of various ages; (2) the conducting of large-scale spraying experiments in vineyards but recently infested, with a view to furnishing protection from the insect and maintaining the present standard of crop production; (3) beginning large-scale experiments to determine the possibility of bringing badly injured vineyards up to a state of profitable production, and to ascertain the best means of furnishing protection to young vineyards just coming into bearing.

EXTENT OF INJURY TO NEWLY BEARING VINEYARDS.

As an illustration of the extent of injury done by this pest to young vineyards which came under the writer's observation during the past summer, the condition of a block of vineyard growing on a level piece of ground in a clay loam soil near the lake shore may be cited. The vines had borne but three crops, and previous to the attack of the grape root-worm were very thrifty. The original planting consisted of 3,234 vines. An examination of the vineyard on June 17, 1907, showed that 543 vines had been so badly injured by the grape root-worm that they had to be cut back to the ground; 897 vines were cut back to the lower wire and bore no fruit that season, and the remaining 1,794 vines were cut back to one or two canes. This treatment, made necessary by root-worm injury, resulted in a curtailment of 75 per cent of the crop.

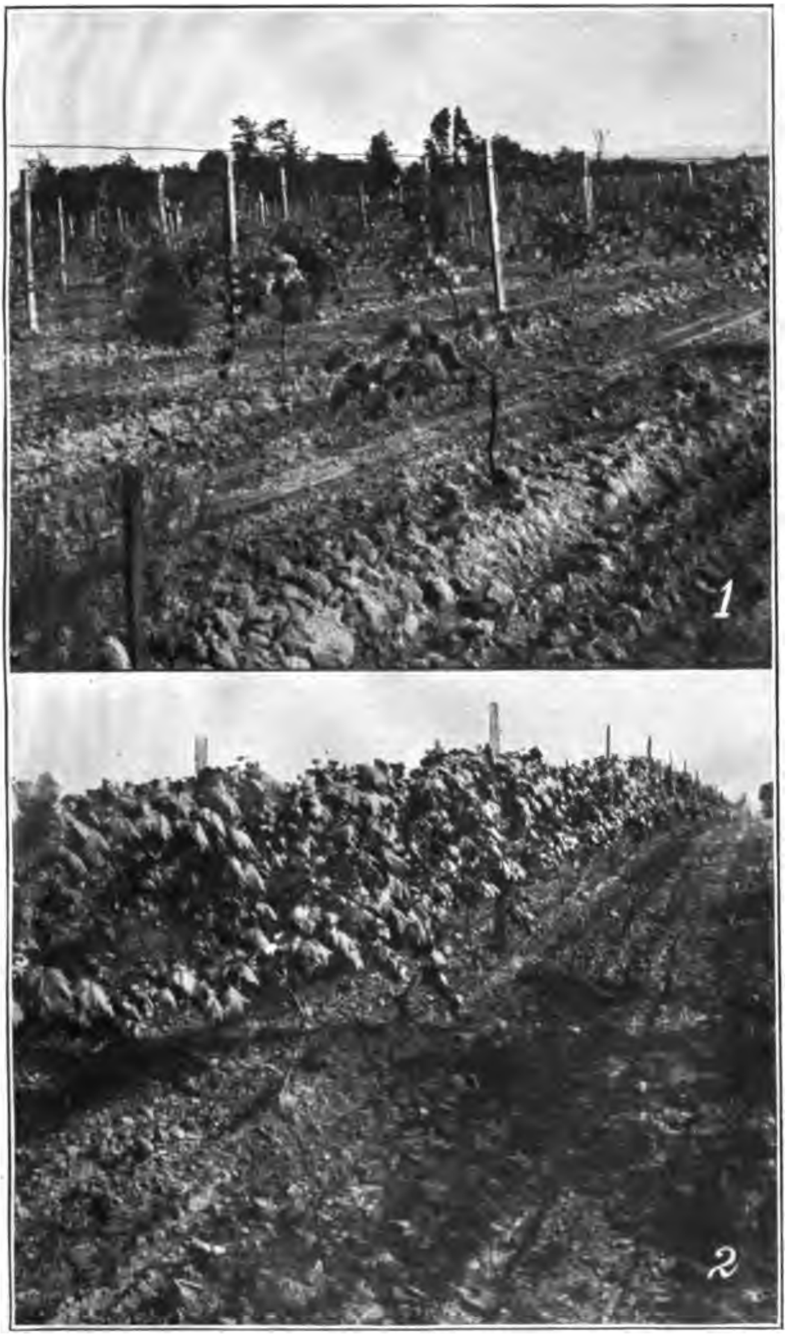
Figure 1, Plate VIII, shows the condition of the above-mentioned vineyard September 2, 1907. Figure 2, Plate VIII, shows vines in a younger vineyard only a few yards distant, bearing their first crop of fruit and not yet infested by the grape root-worm. (The owner informed the writer that at the same age the vines shown in figure 1 were quite as thrifty as those shown in figure 2.)

Another young vineyard, 6 years old, on a loose gravel soil, showed an even worse condition. In one section of 1,620 vines, 485 vines were killed outright in a single season, and nearly all the rest of the vines were so seriously injured that they had to be very severely cut back. The crop record of this vineyard is given below, and shows a decline in crop value, in 1907, of $379.80, or 87.17 per cent less than in 1906.

TABLE 1.—*Crop record of vineyard injured by grape root-worm.*

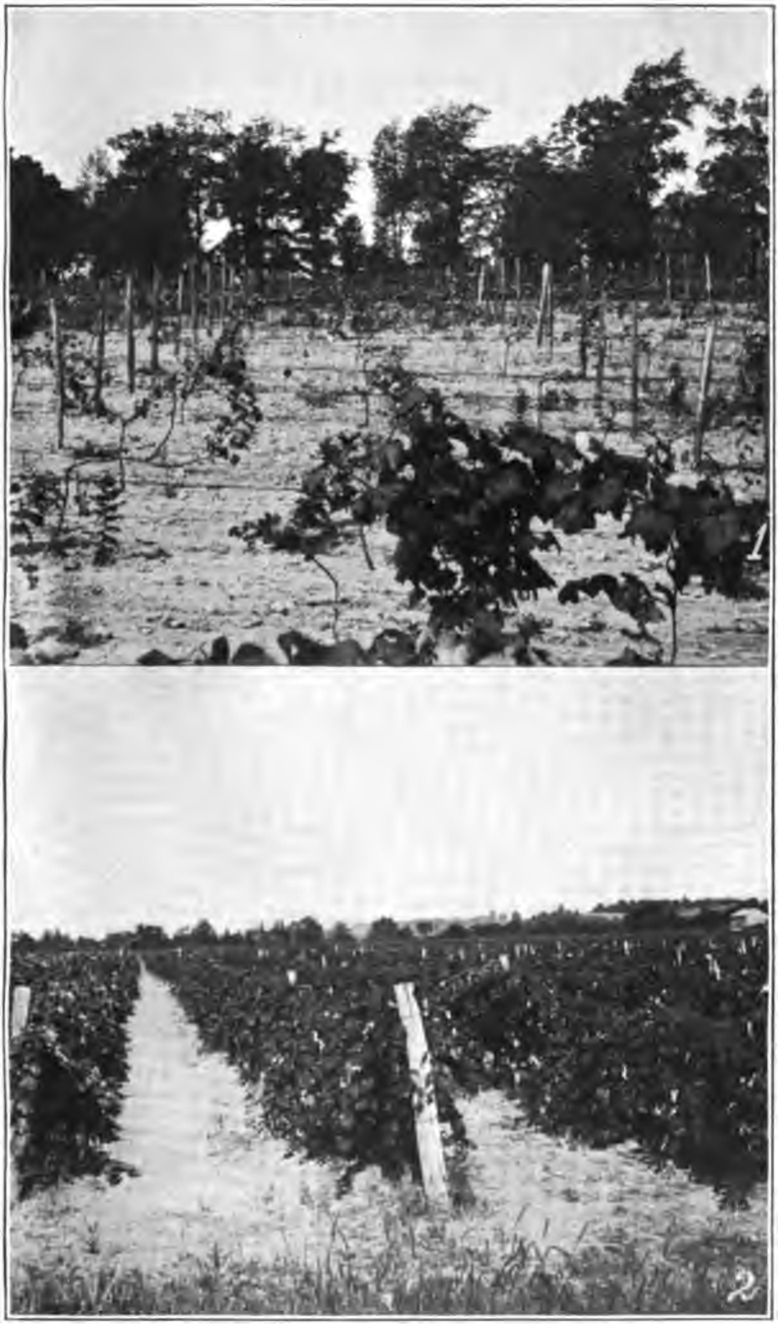
Year.	Number of trays.	Number of baskets.	Net weight.	Value of crop.
			Pounds.	
1904	295	None.	11,630	$127.5
1905	613	696	23,705	410.7
1906	581	588	21,130	435.72
1907	93	None.	3,195	55.92

Figure 1, Plate IX, shows the stunted condition of the vines in the above-mentioned vineyard, as a result of the grape root-worm injury. Figure 2, Plate IX, shows a normally thrifty uninfested vineyard at North East, Pa. It should be stated in addition that both of these injured vineyards had received the best of care, so far as cultivation and general management are concerned, with the exception of spraying the vines to protect them from the beetles, and previous to 1906 both vineyardists were highly pleased with the vigorous condition of their vines. The illustrations cited above are



VINES INJURED BY GRAPE ROOT-WORM COMPARED WITH UNINJURED VINES.

Fig. 1.—Six-year planted vines making but a weak growth because of injury to roots by grape root-worm. Fig. 2.—Two-year planted vines not yet attacked by grape root-worm. At the same age vines in figure 1 were equally thrifty. (Original.)



VINES INJURED BY GRAPE ROOT-WORM COMPARED WITH UNINJURED VINES.

Fig. 1.—Young vines almost ruined by feeding of grape root-worm upon their roots. Fig. 2.—A normally thrifty vineyard at North East, Pa., uninfested by grape root-worm. (Original.)

by no means exceptional, and a careful survey would reveal hundreds of acres of these newly bearing vineyards in various stages of decline. It was to these new vineyards that the vineyardist looked for the maintenance of the industry in the future, but their present condition shows that when unprotected from the grape root-worm they succumb to the attacks of this pest even more rapidly than do old established vines.

This rapid decline in young vines, due to grape root-worm attack, has opened up the question of the advisability of attempting to renovate these old, run-down vineyards, some of which are now yielding a ton or less of grapes per acre and of which there are several thousands of acres throughout the grape belt.

RENOVATION EXPERIMENT ON AN OLD, RUN-DOWN VINEYARD.

Early in the spring of 1907 a vineyard of 10 acres was secured at North East, Pa., which had been so badly injured by the grape root-worm that the decline in grape production had fallen from 3¼ tons of grapes per acre, in 1905, to three-fourths ton per acre in 1907. The vineyard is to receive severe pruning, thorough cultivation, liberal applications of fertilizers, and thorough spraying. This treatment is to continue for a series of years.

The results of this treatment during the past summer are an increased growth of canes over last year, and a great reduction in the deposition of grape root-worm eggs—a direct outcome of the poison spray application, as indicated in the following table:

Table II.—*Showing egg deposition on sprayed and check plats.*

CHECK (UNSPRAYED) PLAT.

Dates of application.	When examined.	Number of egg clusters found.				Estimated number of eggs.	Number of vines.	Number of canes.	Average number of eggs.	
		Large.	Medium.	Small.	Total.				Per vine.	Per cane.
	August 12...	97	150	238	485	11,730	25	76	469.2	154.37

SPRAYED PLATS.

Formula: 5 pounds blue vitriol (copper sulphate), 5 pounds lime, 3 pounds arsenate of lead, 50 gallons water.

Dates of application.	When examined.	Large.	Medium.	Small.	Total.	Estimated number of eggs.	Number of vines.	Number of canes.	Per vine.	Per cane.
PLAT NO. 1.										
July 13..... July 22.....	August 13...	1	21	34	56	1,440	25	56	57.6	25.71
PLAT NO. 2.										
July 13..... July 22.....	August 13...	4	17	25	46	960	25	85	38.4	11.29

As has been previously stated, the wood growth in this vineyard was light as a result of serious injury to the roots of the vines by the grape root-worm and from severe pruning in the spring. For this reason it might be urged by some that this experiment was not a fair test of the efficacy of a poison spray, because, it is said, beetles desert vineyards in this condition for those having a dense foliage. That there were a large number of beetles present, however, is shown by the heavy deposition of eggs in the untreated check, even though the foliage was light.

SPRAYING EXPERIMENT IN A NEWLY INFESTED VINEYARD.

Since a part of the campaign against this pest is to determine if thorough and timely spraying, conducted for a series of years, will prevent the deterioration of thrifty vineyards but recently infested, an experiment was planned in another vineyard. This vineyard is 20 years old, on gravel soil, making a good growth of canes and luxuriant foliage. It is infested with the grape root-worm, but is not yet showing evidence of deterioration. The block contains about 6 acres; 1 acre was left unsprayed for check and the method of examination to determine results was the same as in the preceding experiment.

The following table gives the record of egg deposition in this block, as a result of the spray applications:

TABLE III.—*Showing egg deposition on sprayed and check plats.*

CHECK (UNSPRAYED) PLAT.

Dates of application.	When examined.	Number of egg clusters found.				Estimated number of eggs.	Number of vines.	Number of canes.	Average number of eggs.	
		Large.	Medium.	Small.	Total.				Per vine.	Per cane.
	August 2......	52	136	213	401	8,810	25	69	352.4	127.67

SPRAYED PLATS.

Formula: 5 pounds blue vitriol (copper sulphate), 5 pounds lime, 3 pounds arsenate of lead, 50 gallons water.

Dates of application.	When examined.	Large.	Medium.	Small.	Total.	Estimated number of eggs.	Number of vines.	Number of canes.	Per vine.	Per cane.
PLAT NO. 1.										
July 15... July 23...	August 2......	4	13	13	30	720	25	72	28.8	10
PLAT NO. 2.										
July 15... July 23...	August 2......	4	19	20	43	970	25	61	38.1	15.9

METHODS OF RECORDING RESULTS.

The figures on egg deposition given in the tables above were obtained by carefully removing all of the loose bark from the bearing canes and the trunks of 25 consecutive vines, and recording the number of egg clusters found. Since the egg clusters varied in size, they were classified—after the eggs in a large number of clusters had been counted to ascertain the actual number—as *large*, when containing 50 eggs or over; *medium*, when containing about 30 eggs; and *small*, when containing about 10 eggs. Examinations were made in three parts of the vineyard. An unsprayed check plat of 1 acre was left on one side of the vineyard and the egg clusters found on 25 consecutive vines, at a date after the maximum number of eggs had been deposited, were recorded in the manner just described. A similar examination was made on 25 consecutive vines in the sprayed portion, six rows over from the check plat, and a further examination on 25 sprayed vines on the opposite side of the vineyard, the main object of this last examination being to determine the uniformity of egg deposition throughout the vineyard.

RECOMMENDATIONS BASED ON OBSERVATIONS AND RESULTS OF SEASON'S WORK.

The work of the past season, at North East, Pa., indicates that thorough and timely spraying of infested vines with arsenate of lead will, by preventing the deposition of a sufficiently high percentage of eggs, reduce the number of grape root-worms to such an extent that they will not seriously affect the growth of the vines. In order to make the spray effective, however, the first application must be made either immediately before, or as soon as the first beetle is seen in the vineyard.

Since the emergence of the beetles from the soil is governed largely by weather conditions, especially those of temperature, no definite date for making the first application can be given. For instance, the records of Felt and Slingerland show that in normal seasons the beetles commence to appear during the last week or ten days in June, whereas, in 1907, none was found in vineyards by the writer until July 15, although he had spent a large portion of every day in the vineyards for a week or two preceding that date. Hence, it is very necessary to watch the development of the larvæ and pupæ in the soil.

The emergence of the beetles in our breeding cages during the past season coincides very closely with the appearance of the beetles in vineyards. The first two beetles appeared in the cages on the morning of July 14; by the 15th a large number had emerged, and the same day the beetles were very numerous on foliage in vineyards on gravel soil. Nearly 50 per cent of the beetles which matured from 750 larvæ, placed in the soil in our breeding cages, emerged on the third and fourth days after the first beetle appeared. This simultaneous emergence of so large a percentage of beetles shows the necessity of having the first spray application upon the vines by the time the first beetles appear, or, at least, to have the spraying equipment in readiness so that the application may be made with the least possible delay.

The time of emergence of the beetles can be determined quite closely by examining the condition of the pupæ in the soil every few days [illegible] of May [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]	[illegible]
[illegible]	[illegible]
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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 68, Part VII.

L. O. HOWARD, Entomologist and Chief of Bureau.

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

DEMONSTRATION SPRAYING

FOR THE

CODLING MOTH.

ISSUED APRIL 29, 1908.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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during the latter part of June; or, still better, by collecting a hundred or so full-grown larvæ about the last of May and placing them in a shallow box, the bottom of which consists of a pane of glass, the box containing about 3 inches of moist soil. Some of the larvæ will go through the soil to the glass surface, where their transformations may be watched and the time of emergence definitely determined.

In making the spray applications care should be taken to cover all parts of the foliage. For thorough work, 100 gallons of liquid spray per acre is necessary and a pressure of not less than 100 pounds should be maintained. Two such thorough applications—one as the beetles emerge, and another not more than a week later—judging from the results obtained in our work of the past season, will prove sufficient to reduce the infestation of this insect to a point where it will not seriously affect the vitality of the vines.

The formula used in our experiments during the past season is the Bordeaux mixture formula, recommended by the Bureau of Plant Industry for combating the black rot of the grape, to which was added 3 pounds of arsenate of lead, the latter ingredient being the insecticide.

Spray formula recommended.

Copper sulphate (bluestone or blue vitriol)	pounds	5
Fresh stone lime	do	5
Arsenate of lead	do	3
Water	gallons	50

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PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

DEMONSTRATION SPRAYING FOR THE CODLING MOTH.

INTRODUCTION.

By A. L. QUAINTANCE,

In Charge of Deciduous Fruit Insect Investigations.

Although the codling moth (*Carpocapsa pomonella* L.) has received a large amount of attention from entomologists, horticulturists, and others during the past fifteen or twenty years, and methods for its satisfactory control have long been known and practiced by orchardists, it is nevertheless true that a large number of apple growers either do not spray for this insect or, from lack of thorough and timely applications, do not secure satisfactory results. In connection with other work at some of the field stations in the deciduous fruit insect investigations of the Bureau of Entomology, it has been possible to make demonstration sprayings in the control of the codling moth to serve as object lessons for the orchardists of the neighborhood. The usefulness of the work is shown by its popularity among fruit growers, and indicates that, in general, work of this character is perhaps as much needed as work along purely investigative lines.

DEMONSTRATION SPRAYING IN VIRGINIA IN 1907.

By S. W. FOSTER.

The orchard of Mr. J. J. McHenry, where this demonstration was made, is located near the foot of the Blue Ridge Mountains near Afton, in Nelson County. This orchard site is very favorable, having a northern exposure with an elevation of about 1,000 feet, and being partly protected on the western side by a mixed forest.

Mr. McHenry's orchard consists of about 400 Yellow Newtown Pippin trees and 220 trees of the Winesap, Limbertwig, and Shockley varieties, all of which were reported to be 28 years of age. Some years ago this orchard was very profitable, but the prevalence of the codling moth, together with some of the more important fungous diseases, as bitter rot and apple scab, soon reduced and practically cut off all profits. Along with this the orchard for some time received little or no attention, and only within the last two or three years had there been any attempt toward spraying and the giving of systematic care. But for various reasons, principally that of neglecting to apply sprays at proper times and in a thorough manner, the results had been very unsatisfactory. The work herewith reported, and carried out in cooperation with Mr. W. M. Scott, of the Bureau of Plant Industry, included the entire orchard and was designed to give freedom from the codling moth and fungous diseases as well. The entire orchard was sprayed except a few trees for purposes of comparison.

Location of unsprayed trees used in determining results.—The unsprayed trees used for counts of fruit in this demonstration were selected just prior to the first spraying. With two exceptions the trees were in each of two rows running through the middle of the orchard, five rows apart. Two pippin trees (one to be sprayed and one to be left unsprayed) were also selected near the edge of the orchard for possible comparison with other treated and untreated trees.

Treatment.—As bitter rot and apple scab had in previous years caused serious injury to the fruit in this orchard, a treatment was planned to control both insects and fungous diseases, namely, the application of Bordeaux mixture with an arsenical added. Six applications of Bordeaux mixture were made, using for the first application 4 pounds of bluestone and 6 pounds of quicklime to 50 gallons of water, and for the subsequent applications 5 pounds of bluestone and 5 pounds of quicklime to 50 gallons of water. Arsenate of lead, 2 pounds to 50 gallons of the mixture, was used with the first, second, and fifth applications.

Times of application.—The first application (4–6–50 formula of Bordeaux mixture plus 2 pounds arsenate of lead) was applied just after the blossoms fell, to fill the calyx cavities of the apples with poison, and, owing to continued unfavorable weather, was very much prolonged, from April 30 to May 9. The second application was made three weeks later, about the time it was thought that the moths from the over-wintering larvæ would begin to deposit eggs in numbers, that is, from May 21 to 27; the third application, five weeks later, June 24 to 26; the fourth, July 10 to 13. The fifth, containing arsenate of lead, for the second brood of larvæ, was applied soon after the first adults began to emerge from the cocoons of the first-brood larvæ, July 25 to 29. The sixth, being the last, was a treatment with Bordeaux mixture alone, and was applied from August 12 to 15.

The outfit used consisted of a large hand pump with two horizontal cylinders mounted on a 200-gallon tank, and two leads of hose with 15-foot extension rods, with double Vermorel nozzles. A platform elevated about 4 feet over the rear end of the tank proved very advantageous, especially for the first application, as it enabled one man to cover the tops of the trees completely and direct the spray downward.

Results.—The following tables show the comparative results from sprayed and unsprayed trees:

Table I.—*Comparison of sound and wormy fruit from 5 sprayed and 5 unsprayed trees, Winesap variety, McHenry orchard, Afton, Va., 1907.*

Date of spraying and tree number.	Total crop.	Windfalls.			Fruit from tree.			Total wormy.	Total not wormy.	Total number of apples.	Per cent sound fruit.
		Wormy.	Not wormy.	Total.	Wormy.	Not wormy.	Total.				
Sprayed Apr. 30, May 21, June 24, July 10, July 25, Aug. 12.	*Bushels.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	
Tree 1	19.25	37	168	205	217	4,008	4,225	254	4,176	4,430	94.26
Tree 2	11.75	26	180	206	165	2,567	2,732	191	2,747	2,938	93.50
Tree 3	12.75	42	126	168	97	2,631	2,728	139	2,757	2,896	95.20
Tree 4	8.25	43	172	215	36	1,670	1,706	79	1,842	1,921	95.88
Tree 5	11.00	56	180	236	87	2,155	2,242	143	2,335	2,478	94.23
Trees 1 to 5 combined	63.00	204	826	1,030	602	13,031	13,633	806	13,857	13,663	94.50
Unsprayed:											
Check A	7.00	715	54	769	531	318	849	1,246	372	1,618	22.99
Check B	9.25	1,255	115	1,370	521	291	812	1,776	406	2,182	18.60
Check C	5.50	455	53	508	419	309	728	874	362	1,236	29.28
Check D	5.00	532	85	617	307	196	503	839	281	1,120	25.08
Check E	5.50	660	62	722	475	201	676	1,135	263	1,398	18.81
A, B, C, D, E, combined	32.25	3,617	369	3,986	2,253	1,315	3,568	5,870	1,684	7,554	22.29

Table I shows an average of 94.50 per cent of fruit not wormy from the sprayed trees against 22.29 per cent of fruit not wormy from the unsprayed trees. This is a saving of 72.21 per cent of the crop in favor of sprayed trees.

Table II.—*Comparison of sound and wormy fruit from 5 sprayed and 5 unsprayed trees, Newtown (Albemarle) Pippin variety, McHenry Orchard, Afton, Va., 1907.*

Date of spraying and tree number.	Total. crop.	Windfalls.			Fruit from tree.			Total wormy.	Total not wormy.	Total number of apples.	Per cent sound fruit.
		Wormy.	Not wormy.	Total.	Wormy.	Not wormy.	Total.				
Sprayed Apr. 30, May 21, June 24, July 10, July 25, Aug. 12:	*Bushels.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	
Tree 1	14.25	28	392	420	49	3,044	3,093	77	3,436	3,513	97.81
Tree 2	13.75	53	473	526	31	2,355	2,386	84	2,828	2,912	97.11
Tree 3	13.75	42	447	489	114	2,160	2,274	156	2,607	2,763	94.36
Tree 4	21.25	124	608	732	164	3,186	3,350	288	3,794	4,082	92.95
Tree 5	18.00	116	1,010	1,126	192	2,653	2,845	308	3,663	3,971	92.24
Trees 1 to 5 combined	81.00	363	2,930	3,293	550	13,398	13,948	913	16,328	17,241	94.70
Unsprayed:											
Check A	23.50	1,504	611	2,115	2,240	1,089	3,329	3,744	1,700	5,444	31.22
Check B	12.00	929	316	1,245	980	389	1,369	1,909	705	2,614	26.96
Check C	11.00	1,380	129	1,509	444	166	610	1,824	295	2,119	13.92
Check D	9.50	1,348	89	1,437	372	126	498	1,720	215	1,935	11.11
Check E	12.00	536	353	889	1,604	26	1,630	2,140	379	2,519	15.04
A, B, C, D, E, combined	68.00	5,697	1,498	7,195	5,640	1,796	7,436	11,337	3,294	14,631	22.51

The five sprayed trees show an average of 94.70 per cent of fruit not wormy as against 22.51 per cent, the average percentage of fruit not wormy from the unsprayed trees. This is a saving of 72.19 per cent of the crop for the treated trees.

Leaving out the wear of apparatus, such as pump, wagon, etc., the cost of the six applications for the entire orchard is given as follows: Two men 22½ days at $1.25 per day, $56.25; 2 men 22½ days at $1 per day, $45; 2 horses 22½ days at $1 per day, $45, making a total cost for labor of $146.25.

For the 620 trees, 14,100 gallons of spray were required, the material costing as follows: Arsenate of lead, 324 pounds at $0.125 per pound, $40.50; copper sulphate, 1,260 pounds at $0.08¾ per pound, $110.25; lime, 11 barrels at $0.80 per barrel, $8.80, making a total cost for material and labor of $305.80, or an average cost for all spraying of 49 cents per tree.

The 5 sprayed Winesap trees gave a yield of 18 barrels of No. 1 apples, 1 barrel of No. 2's, and one-half barrel of culls. The price received for these grades of red fruit was $3.25, $2, and $1.75, respectively, per barrel. This gives a total receipt of $61.35 for the 5 sprayed trees or $12.27 per tree. This, minus 49 cents, the cost of spraying, leaves a net return of $11.78 per tree. The yield of the 5 unsprayed trees was 1¼ barrels of No. 1 apples, 1 barrel of No. 2's, and 3 barrels of culls, giving a total return of $11.31 for the 5 trees, or $2.26 per tree, leaving a difference of $9.25 as a net gain per tree in favor of the sprayed trees.

The net gain was even more favorable with the Yellow Newtown Pippin variety, the 5 sprayed trees yielding 20½ barrels of No. 1 apples, 1 barrel of No. 2's, and one-half barrel of culls. The prices received for these grades of this variety were $4.25, $3, and $1.75, respectively, per barrel, giving a total of $90.97 for the 5 trees, or $18.19 per tree. This, minus 49 cents, the cost of spraying, leaves a net return of $17.70 per tree. The 5 unsprayed trees gave only 1¾ barrels of No. 1 apples, 3 barrels of No. 2's, and 7½ barrels of culls; at the same price this gives a total of $29.12 for the fruit from the 5 unsprayed trees, or $5.82 per tree, leaving a difference for the sprayed trees of $11.88 net gain per tree.

DEMONSTRATION SPRAYING IN PENNSYLVANIA IN 1907.

By Fred Johnson.

The apple orchard used in this demonstration is situated on a high bluff along the shore of Lake Erie about a mile north of the village of North East, Pa. It is bounded on three sides by steep banks, with woods on the north and east, and open on the south and west. There are about 250 trees in the orchard, consisting mainly of Baldwins, with several rows of Greenings on the north side which were not used in the work. The trees are about 30 years old; most of them about 25 feet high, with corresponding spread of limbs.

Previous to the spring of 1907 the orchard had been in sod for many years, and no pruning had been done for a like period. The orchard was kept under observation during the summer of 1906, and the condition of the fruit at harvest time was carefully noted. Under the management to which the orchard had been subjected for many years, the grass had been cut for hay, no spraying had been done, and no fruit had been picked from the trees, although in 1906 the ground beneath a large number of them was covered with fallen fruit, indicating that a fair crop of fruit had set. Some of this fruit was picked up and sold at $0.17 per hundredweight for cider-making purposes. Practically all of this fruit was injured by the codling moth and the plum curculio.

On September 5, 1906, a Baldwin tree was selected as fairly representing the condition of the trees in the orchard, and all of the fruit then on the ground was picked up and classified as to injury by codling moth and plum curculio, and all fruit which fell to the ground after this date, and that picked at harvest time, was likewise classified.

The total picked and dropped fruit, amounting in all to 2,766 apples, showed 95.62 per cent injury by the codling moth, and 62.55 per cent bearing egg and feeding punctures of the plum curculio.

The owner of the orchard, at the suggestion of the writer, decided to prune and cultivate the orchard in 1907, and it was placed at the disposal of the Bureau of Entomology for spraying experiments. The trees were pruned very early in the spring and the sod broken up and cultivated twice later in the summer. One hundred and fifty trees, all Baldwins, with the exception of a few scattered Astrachans, were laid out into 15-tree plats, including a check plat, and treated with Bordeaux mixture and an arsenical in a way to ascertain the value of applications at different dates. One of these plats received the usual "demonstration" treatment for that latitude, and it is from this plat and the check plat that the data to be given were obtained.

Three applications of spray were made: (First) June 10, immediately after petals fell; (second) July 2, three weeks later, when first eggs of codling moth were being deposited; (third) August 9, when adults were beginning to emerge and to deposit eggs for the second brood. The 5-5-3-50 formula was used—that is, 5 pounds copper sulphate, 5 pounds stone lime, 3 pounds arsenate of lead, and 50 gallons of water.

The applications were made with a gasoline-power sprayer mounted on low trucks, with a 4-foot derrick, using 10-foot bamboo rods and double nozzles. In the operation of spraying a pressure of about 100 pounds was maintained and between 4 and 5 gallons of liquid were used per tree at each application.

The sprayed trees were separated from the untreated check trees by two rows of trees which were also sprayed to act as a barrier and to prevent the overflow of codling moth which might breed on the unsprayed plat during the summer.

Table III gives the results obtained from three trees in both the sprayed and unsprayed plats, by actual count and examination of windfalls and picked fruit.

TABLE III.—*Comparison of sound and wormy fruit from 3 sprayed and 3 unsprayed trees, Baldwin variety, Sprague Orchard, North East, Pa., 1907.*

Dates of spraying and tree number.	Total crop.	Windfalls.			Fruit from tree.			Total wormy.	Total not wormy.	Total crop.	Per cent sound fruit.
		Wormy.	Not wormy.	Total.	Wormy.	Not wormy.	Total.				
Sprayed June 10, July 2, and August 9:	*Bushels.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	
Tree No. 1	9.25	22	235	257	19	2,151	2,170	41	2,386	2,427	98.31
Tree No. 2	5.50	74	264	338	17	1,279	1,296	91	1,543	1,634	94.43
Tree No. 3	5.50	76	281	357	26	1,099	1,125	102	1,380	1,482	93.12
Trees Nos. 1 to 3 combined	20.25	172	780	952	62	4,529	4,591	234	5,309	5,543	95.7
Unsprayed:											
Check A	3.00	324	34	358	547	90	637	871	124	995	12.46
Check B	3.75	559	262	821	303	237	540	862	499	1,361	36.66
Check C	5.25	599	255	854	626	222	848	1,225	477	1,702	28.03
Checks A to C combined	12.00	1,482	551	2,033	1,476	549	2,025	2,958	1,100	4,058	27.11

Table IV gives the yield of windfalls and picked fruit in bushels and its market value for 14 trees in the sprayed plat and for the same number of trees in the unsprayed plat.

TABLE IV.—*Comparison of yield and character of fruit from 14 sprayed and 14 unsprayed trees, Baldwin variety, Sprague Orchard, North East, Pa., 1907, with value of crop.*

Date of spraying.	No. of trees.	First-class apples.	Second class apples.	Canners.	Ciders.	Total.	Value first class.	Value second class.	Value canners.	Value ciders.	Total value.
		Bush.	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*
June 10, July 2, and August 9	14	43.25	20.25	4	20.75	88.25	43.25	13.50	1.20	3.10	61.05
Unsprayed checks	14	....	....	22	58.00	80.00	....	....	6.60	8.70	15.3

The picked fruit was packed in two grades, the first grade bringing $3 per barrel, the second grade $2 per barrel. The windfalls and culls were also sorted into two grades. Those above 2 inches were used for canning and sold for 60 cents per hundredweight, while those of the smaller grade were used for cider-making purposes and sold for 30 cents per hundredweight.

The total amount of spray applied to the 14 trees was 182 gallons, about 13 gallons per tree for the three applications, at a cost of about 2 cents per gallon, or $3.64 for the 14 trees.

The time required to make the applications was about one and one-half hours for each time, or about four and one-half hours for the three applications.

Two men and a team were used in the work, and the wage paid was 40 cents per hour for man and team, and 17.5 cents per hour for the additional man, making the cost of labor $2.59 for the four and one-half hours, the total cost of labor and material being $6.23. Allowing $1 for gasoline and wear and tear on the machine, there was a total expenditure of $7.23. Deducting this amount, together with $15.30 (the value of the crop from the untreated check plat), from $61.05 (the value of the crop from the sprayed plat), there is a net gain of $38.52 on the 14 trees, or $2.75 per tree for the sprayed trees.

DEMONSTRATION SPRAYING IN OHIO IN 1907.

By A. A. GIRAULT.

An orchard belonging to Mr. A. P. Roudebush, a prominent farmer and fruit grower of Owensville, Clermont County, Ohio, and one of the largest in that vicinity, was selected for this spraying demonstration against the codling moth. This orchard consisted of about 400 trees of such well-known varieties as Ben Davis, Rome Beauty, Grimes Golden, etc. The orchard was in sod; the trees were vigorous, from about 25 to 30 feet tall, and well shaped, but needed thinning. During the past two or three years they had been treated with not more than two applications of Bordeaux mixture and arsenate of lead. The codling moth was a well-established pest in this orchard, and the owner was discouraged over the difficulties which he had encountered in combating it.

The plat selected for this work consisted of a single row of 27 Ben Davis trees, 10 years of age, in the southwestern portion of the orchard, and adjoining an orchard of young trees; in the center of the next row to the northeast 10 trees of similar variety and age were left untreated for purposes of comparison. Four applications of Bordeaux mixture and an arsenical were made, using 5 pounds of lime, 5 pounds of bluestone, 2 pounds of arsenate of lead, and 50 gallons of water. Spraying was done on the following dates: May 10, June 14, July 25-26, and August 15. The table below shows the results, as determined from 5 sprayed and 5 unsprayed trees in each plat:

TABLE V.—*Comparison of sound and wormy fruit from 5 sprayed and 5 unsprayed trees, Ben Davis variety, Roudebush Orchard, Owensville, Ohio, 1907.*

Date of spraying and number of trees.	Total crop.	Windfalls.			Fruit from tree.			Total wormy.	Total not wormy.	Total crop.	Per cent sound fruit.
		Wormy.	Not wormy.	Total.	Wormy.	Not wormy.	Total.				
	Bushels.	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	
Sprayed May 10, June 14, July 25, and August 15: Trees 1 to 5 combined......	9.80	78	1,997	2,075	121	1,571	1,692	199	3,568	3,767	94.72
Unsprayed. Checks A to E combined.....	3.25	1,992	2,218	4,210	651	68	719	2,643	2,286	4,929	46.38

The tabulated results show that the four applications gave about 94 per cent fruit free from codling moth injury and trebled the yield in bushels, while the total marketable crop in bushels was more than twice doubled. In the checks the percentage of wormy fruit in the total yield was 46.38 per cent, whereas in the sprayed trees it was but 5.28 per cent. The contrast between the treated and untreated trees at harvest time was marked, even to the casual eye, because the latter had been partly defoliated by various leaf-feeding insects, and the attack of the codling moth and plum curculio had been disastrous to the fruit yet remaining; whereas the foliage and fruit of treated trees were in almost perfect condition. The four treatments also prevented over 50 per cent of the injury of the plum curculio, which is a more serious enemy of apples in this vicinity than is the codling moth.

The four applications required 450 gallons of the mixture at a cost of $0.016 per gallon, a total cost of $7.20 for the Bordeaux mixture and poison. Adding the cost of labor for 2 men at $1.50 per day and a team at $2 per day for one and one-half days, which is $7.50, the cost of the whole operation was $14.70, or at the rate of $0.54 per tree. Placing the price of apples per bushel at $1, the net returns from a single unsprayed tree would be about 36 cents, whereas the net returns from a single sprayed tree would be $1.31, a net gain of about 95 cents per tree. As will be seen from the table, the crop in this orchard was quite light. With a normal crop the percentage of benefit would have been much larger.

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L. O. HOWARD, Entomologist and Chief of Bureau.

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES

THE GRAPE-LEAF SKELETONIZER.

BY

P. R. JONES,
Engaged in Deciduous Fruit Insect Investigations.

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U. S. D. A., B. E. Bul. 68, Part VIII. D. F. I. I., January 20, 1909.

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE GRAPE-LEAF SKELETONIZER.

(*Harrisana americana* Guérin-Méneville.)

By P. R. Jones,
Engaged in Deciduous Fruit Insect Investigations.

INTRODUCTION.

For the last sixty years or more the species known as *Harrisana americana* has been brought to the attention of entomologists and vineyardists by the characteristic feeding of the yellowish, black-spotted larvæ in soldierlike rows upon the foliage of the grape. As this is the only Lepidopterous insect that feeds in a gregarious manner upon grape foliage it will be easily recognized. Although it has been known for a number of years, many points have been lacking in the knowledge of its life history and habits, and it is hoped that the following pages will present some facts that hitherto have not been mentioned, as well as give a summary of what has been learned about the insect up to the present time.

HISTORY.

There is considerable doubt as to where this insect was first figured and described. In G. Henderson's edition of the Animal Kingdom it is figured by Baron Cuvier (1837) under the name *Agloape americana* Boisduval, but no description is given. A description and figure are published by Guérin-Méneville, the insect being listed as *Agloape americana* Boisduval. The dates of issue in the latter case (1829–1838) are evidently erroneous, as there are in the volume frequent references to articles published in 1840, 1841, and some as late as 1843; the volume was, therefore, probably not issued before 1844 or 1845. Harris, in 1839, described the species as *Procris americana* and figured its various stages. This appears to be the first published description, as Harris says in a note after the description: "This insect appears to be the same as the one figured in Guerin's Iconographie and Griffith's Cuvier, under the name of *Agloape americana* Boisduval, but it is not an Agloape, for it has a distinct spirally-rolled tongue." He makes no mention of a description and apparently had not seen any. The specific name should be attributed to Guérin-Méneville, as he is the author of the book in which the figure first appeared, and because he does not at any place give specific credit to Boisduval, who undoubtedly described it.

The first economic account of the insect appears in Hovey's Magazine of Horticulture for June, 1844, where Harris, under the name *Procris americana*, gives a full account of its relation to European species, its natural food plants, life history, and habits. He mentions it as first brought to his notice in 1830 by Professor Hentz, who found larvæ upon a vine at Chapel Hill, in North Carolina.

In 1855 Townend Glover reports it as injurious in the vicinity of Washington, D. C., and gives a short general account.

Harris, in 1862, gives an account of it which is practically the same as the one which appears in Hovey's Magazine, but shorter.

Walsh (1866) next determines the insect and gives a short account of it, in answer to a letter.

In 1867 C. V. Riley gives a brief account, with notes on its life history and habits. Bethune then (1867) published a short general account of it.

In 1869 Walsh and Riley determined some insects to be *Procris americana* Boisduval. Riley (1870) gives the most detailed account published up to the present date and treats of its identity, food plants, life history and habits, natural enemies, and remedies. During the same year he again writes concerning it, but the account is taken from the previous one.

Lintner (1879) gives a short general account and again (1883) mentions it in answer to a letter. The next account of it is a short account by Atkinson, in 1888.

Neal, in 1890, presents most of the knowledge up to the present date and records some original observations as to the number of broods and varieties of grapes preferred.

Toumey (1893) records it from two localities in Arizona and gives a short review of its manner of working.

J. B. Smith (1895) next writes concerning it and gives a detailed account of its life history and habits, with some new points on local distribution. During the same year (1895) Slingerland reviews the chief points in its life history in answer to a letter.

Starnes (1898) gives a general account of it and mentions the fact of its being more prevalent in the West and South than in the East.

The latest economic reference is that of J. B. Smith (1903), who figures it as one of the insects sometimes troubling grapes.

ORIGIN AND DISTRIBUTION.

The grape-leaf skeletonizer is probably a native species, from the fact that it feeds upon Virginia creeper and wild grapes in addition to the domestic varieties of grape. Harris mentions it as related to *Procris ampelophaga*, of Europe, which is injurious to the vineyards of Piedmont and Tuscany, and Riley states that it is related to the European *Procris vitis.*

In literature it has been recorded from the following States and Provinces: Canada (Bethune); New England (Walsh); New York (Slingerland); New Jersey (Smith); Washington, D. C. (Glover); North Carolina (Walsh); Georgia (Starnes); Florida (Neal); Ohio (Lintner); Missouri (Riley); and Arizona (Toumey).

In the files of the Bureau of Entomology there are records as follows: Orange, N. J.; Dalton, Philadelphia, and Williamsport, Pa.; Berwyn, Cambridge, Sharptown, and Sullivan, Md.; Washington, D. C.; Afton, Va.; French Creek and Lewisburg, W .Va.; Raleigh, N. C.; Columbia and Timmonsville, S. C.; Poulan, Ga.; Jacksonville, Oakland, Stephensville, and Umatilla, Fla.; Auburn, Ala.; Masengale and Poplarville, Miss.; Mandeville and New Orleans, La., and Hermosillo, Mexico.

FOOD PLANTS AND DESTRUCTIVENESS.

Harris states that this species feeds very readily upon *Ampelopsis quinquefolia;* Riley writes that its natural food is Virginia creeper and wild grapes; while both record it as being fond of cultivated grapes. Toumey states that it was found upon *Vitis arizonica*, and Neal records it as living naturally upon wild grapes and Virginia creeper but that it prefers cultivated grapes, especially if exotic or choice. Riley mentions that a Mr. Jordan, of St. Louis, Mo., states that it attacks Concords but never the Clinton or Taylor varieties in his vineyards. During the past summer the writer noticed that it was especially fond of certain hothouse varieties in an abandoned greenhouse upon the Department grounds.

CHARACTER OF INJURY.

The young larvæ during the first three or four instars feed only on the outer epidermal layer of the leaf, completely skeletonizing it. (See fig. 12.) This is done on both the upper and lower surfaces; according to the writer's observation there is preference for the upper surface, but several entomologists record the lower surface as being preferred. Later the larvæ, which until now have fed in a row side by side, separate into single individuals or into small groups and eat the whole tissue of the leaf except the larger veins.

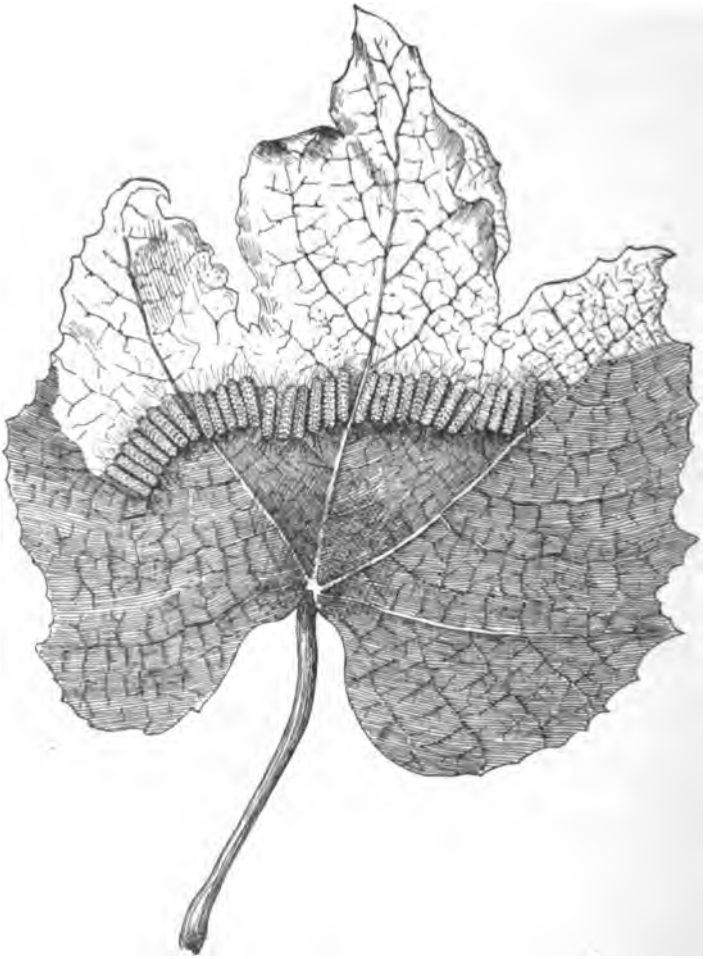

FIG. 12.—The grape-leaf skeletonizer (*Harrisana americana*): Young larvæ feeding on leaf. (Original.)

DESCRIPTION.

EGG.

The egg (fig. 13) is small, shining, dilute lemon-yellow in color, cylindrical-oval or capsule shaped, with an irregular hexagonal sculpturing. From a number of eggs measured the maximum length is 0.600 mm. and the minimum 0.533 mm.; the maximum width is 0.383

mm. and the minimum 0.316 mm. The average size of the egg is 0.566 mm. by 0.349 mm.

The eggs are deposited on the underside of the leaves in clusters, and from 12 clusters counted, the minimum contained 7 eggs, the maximum 260, the average cluster containing 107.9 eggs. Observations on 1,035 eggs gave the average length for the egg stage as 7.92 days, with a maximum of 9 days and a minimum of 7 days, the average mean temperature for the period of incubation of the various eggs being 77.5° F., with cloudy weather prevailing. The eggs under observation were from the second generation of moths, and the length of the stage would probably be somewhat greater for the first generation on account of lower temperature.

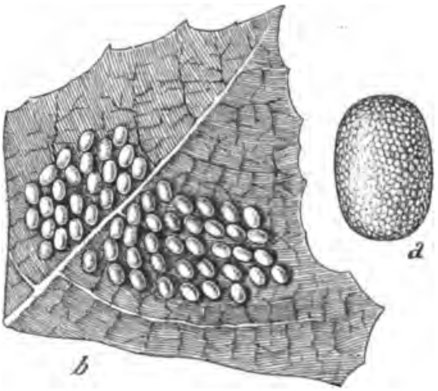

Fig. 13.—The grape-leaf skeletonizer (*Harrisana americana*): *a*, Egg, greatly enlarged; *b*, cluster of eggs in natural position on leaf. (Original.)

LARVA.

First instar.—Body yellowish-white, translucent. Head similar in color to body, retractile, broader than body, which gradually tapers. Segments 2–13 with a transverse median row of spinelike bristles, about 0.2 mm. in length, extending to venter on each side; whitish when viewed under a ⅔-inch objective, but the dark-colored joints cause them to appear blackish under a small magnification. Thoracic feet small, pointed, color similar to body; abdominal feet small, visible only as small wartlike protuberances. Length, 1–1.25 mm.; width of head, 0.18–0.25 mm. (variable).

Second instar.—Body dilute-yellow, head retractile, darker, eyes and mandibles dark brown. Tubercular areas now distinct under a ⅔-inch objective as a transverse row of wartlike clusters of whitish, segmented bristles about 0.2 mm. in length, with apex, joints, and bulb at base of the bristles black. All the segments laterally, and dorsum of the anterior and posterior segments with long, whitish, segmented hairs about 0.75 mm. in length. Thoracic feet small, pointed, dilute-brownish; abdominal feet, more distinct now, appearing as small stumplike projections. Length, 1.666–2 mm.; width of head, 0.283–0.333 mm.

Third instar.—Body orange-yellow, head retractile, dilute-brown, eyes and mandibles brownish-black. Segments 2–13 show wartlike tubercles, with bristles similar to those in the preceding instar. 0.2–0.25 mm. in length, with the black on the apices, joints, and bulbs at the base more pronounced, causing the tubercles to appear black to the naked eye. All the segments laterally, and dorsum of the anterior and posterior segments with long, segmented, whitish hairs variable in length. Thoracic feet small, pointed, dilute-brown, darker at the tip; abdominal feet larger, apex with a circlet of black bristles, all the feet similar in color to the rest of the body. Length, 3.5–4.5 mm.; width of head, 0.666 mm. (nearly constant).

Fourth instar.—Body sulphur-yellow, head retractile, dilute-brown, darker on exposed portion, mandibles and eyes brownish-black. Head when viewed from above oval-pyramidal in form. Tubercular areas very prominent now to naked eye, appearing as black, bristly, wartlike patches, this appearance due to the black tips of the whitish, jointed bristles; joints and bulbs at base of bristles blackish. Tubercular areas on dorsum of segments 7, 8, 9, and more especially 7 and 9, fainter to naked eye than on other segments, as the bristles are not so heavily tipped with black nor are the joints black. Dorsum of anterior and posterior segments and all segments laterally with long, whitish, segmented hairs of variable length. Thoracic and abdominal feet yellowish, longer, but marked the same as in the third instar. Length, 7–8 mm.; width of head, 1.05–1.06 mm. (nearly constant).

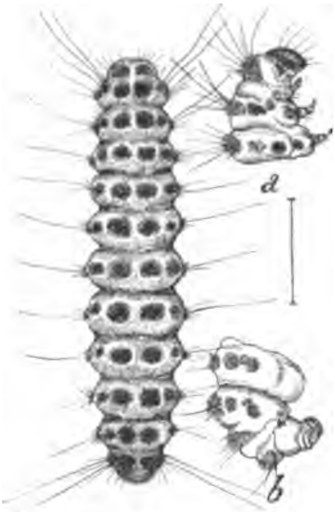

FIG. 14.—The grape-leaf skeletonizer (*Harrisana americana*): Full-grown larva, at left; *a*, lateral view of head and prothoracic segments; *b*, lateral view of posterior segments. Enlarged. (Original.)

Fifth instar.—Body deep sulphur-yellow, head retractile, dilute-brown, darker on exposed portion, mandibles and eyes brownish-black. Shape of head similar to that in the fourth instar. Tubercular areas now very prominent to naked eye and appearing as black, bristly, wartlike patches. Bristles under ⅔-inch objective same as in the fourth instar, but more distinct and longer (0.20–0.33) mm. in length). Tubercular areas distinct on all segments, and to naked eye with a slight opaque-bluish cast. Dorsum of anterior and posterior segments, and all segments laterally, with long, segmented, whitish hairs, longer than in fourth instar. Thoracic feet yellow, tipped with black; abdominal feet yellow, with a terminal circle of black bristles. Length, 8–10 mm.; width of head, 1.15–1.45 mm. (variable).

Sixth instar (*full-grown larva*) (fig. 14).—Cylindrical and uniform in shape, color deep sulphur-yellow. Head oval-pyramidal in form, dark brown, lighter above, retractile, concealed beneath first prothoracic segment. Mandibles and maxillæ dark brown, maxillary palpi yellow, translucent, eyes black. Tubercles flat, wartlike areas, appearing to naked eye as a transverse, median row of black dots. Under a ⅔-inch objective, tubercles wartlike, covered with short, thick, segmented, white bristles tipped with black, joints and bulb at base of bristles dark colored (length, 0.20–0.33 mm.). Tubercles arranged: I, subdorsal; II and III, lateral; III, just above spiracle; IV, substigmatal; V, above base of leg. Subdorsal tubercles confluent on segment 2. Segments 5–14 with tubercle III wanting, segments 7–14 with tubercle V wanting, subdorsal and lateral tubercles confluent on segment 13, subdorsal tubercle confluent on segment 14, the rest wanting. Anterior and posterior segments dorsally and all segments laterally with a number of long, whitish, segmented hairs, variable in length. Spiracles round, light brown, present on first prothoracic and on all abdominal segments except anal, the one on segment 13 smaller than the rest. Thoracic feet translucent, yellow, small, pointed, with a single black claw at tip and also a few light-colored hairs on sides. Abdominal feet pale yellow, apex with a row of small, black, bristle-like claws. Length, 11–13.5 mm.; width of head, 1.483–1.666 mm. (variable).

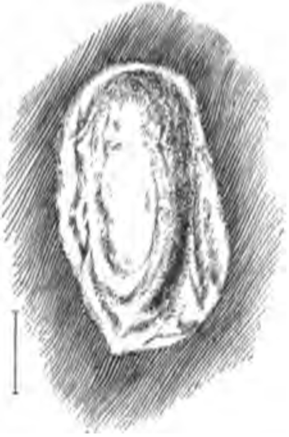

FIG. 15.—The grape-leaf skeletonizer (*Harrisana americana*): Cocoon. Enlarged. (Original.)

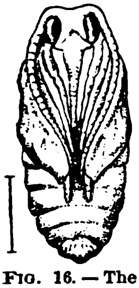

FIG. 16.—The grape-leaf skeletonizer (*Harrisana americana*): Pupa. Enlarged. (Original.)

COCOON.

Cocoon (fig. 15) flat, oblong-oval in shape, composed of a tough, white, cottony, parchmentlike material, opaque when dry, but showing pupa underneath when wet. Length, 10–12 mm.; width, 5 mm.

PUPA.

Pupa (fig. 16) uniformly orange-colored in fresh specimens, brown in older ones; oblong-oval, broadest at abdominal segments 3, 4, and 5. Eyes and spiracles darker than rest of body. Spiracles raised wartlike projections, subconical in shape, eight pairs, the eighth pair the longest. Spiracles arranged on latero-dorsal aspect of abdominal segments 2–9. Anterior third of dorsum of abdominal segments 3–8 covered with very short, decumbent black bristles, the row not extending quite as far as the spiracles on either side. Cremaster wanting, replaced by six very short black bristles which are nearly obsolete in some specimens and appear as black dots. Bristles arranged on the submedio-dorsal aspect of the anal segment as two median pairs and one lateral bristle on the outside of the median pairs. Wing sheaths, and leg sheaths of first pair of legs, subequal, antennal sheaths longer, all extending to about fifth abdominal segment, those of third pair of legs projecting slightly beyond. Length, 6–9 mm.

Observations upon a number of pupæ during the month of July, 1908, in Washington, D. C., show the minimum length of this stage to be 9 days, the maximum 12 days, while the average length for the period is 10.9 days. The average number of days spent in the cocoon is 14.8. The average mean temperature for the month of July, or the time the pupæ under observation were in the cocoons, was 78° F.

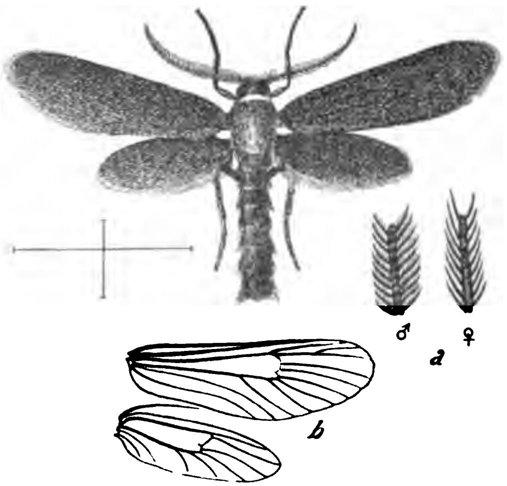

FIG. 17.—The grape-leaf skeletonizer (*Harrisana americana*): Male moth; *a*, antenna of male at left, of female at right; *b*, venation of front and hind wings. Enlarged; *a*, much enlarged. (Original.)

ADULT.

(Fig. 17.)

Uniformly blue-black, except a yellow collar which extends nearly to ventral side. Wings, legs, and eyes similar in color to rest of body. Antennæ pectinate, more so in male than in female, and plumose in male, length about five-sixteenths of an inch in male, four-sixteenths of an inch in female. Abdomen longer, more slender in male than in female and curved upward. Abdomen with a fan-shaped, somewhat bilobed caudal tuft.

Length of moth, 8–11 mm.; length of wing, 11 mm.

Expanse of wing, 22–24 mm.

The following is the original description by Harris:

> Blue-black, with a saffron colored collar and a fan-shaped, somewhat bilobed, black caudal tuft. Expands from 10 lines to 1 inch.

SEASONAL HISTORY.

NUMBER OF GENERATIONS.

Former writers have generally attributed two generations and a partial third to this insect; in fact, all, with the exception of Neal, who states that there are three broods in Florida, are of the opinion that there are two broods. Extended observations and studies during the past summer reveal the fact that there are not two full generations in the vicinity of Washington, D. C. Seasonal history studies show that moths from the over-wintering pupæ appear during the latter part of May or chiefly during the first ten days of June. Eggs from these moths were found June 11, 1908, and also a few very young larvæ. By June 30 some larvæ were almost fully grown, but the majority of full-grown larvæ did not appear until about July 14, although a number of pupæ from the early-developing larvæ were found on July 7, showing a long period from the appearance of the first full-grown larvæ to the appearance of those which attained their growth at the latest date.

The second generation of moths, or those from first-generation larvæ, appeared continuously from July 18 to August 15, giving a very extended period of emergence and accounting for the tendency of former writers to attribute the late-appearing ones to a third generation.

The largest number of moths appeared from July 20 to 25. A number of those larvæ which had attained their growth by July 14 hibernated as pupæ and did not emerge as moths, thus showing clearly that there was not a full second generation.

Eggs from the second-generation moths were most numerous from July 20 to 23, with many second-generation larvæ appearing on July 27. Some of the second-generation larvæ were full-grown on August 24 and were spinning cocoons on that date and up to September 16, when all had gone into cocoons.

LIFE CYCLE.

The average length of the life cycle was found by adding together the average lengths of egg stage, larval period, time spent in cocoon, and life of moth. The average length of the egg stage was 7.92 days, the average length of the larval period 40.5 days, the average time spent in cocoon 14.8 days, and the average length of life of a moth 3.5 days; thus, the average length of the complete life cycle was found to be 66.72 days. The minimum life cycle, found by taking the minimums of the various periods and adding them together, was 53 days.

All of these averages were taken from a very large series under observation. While the above figures should not be taken and used to find how many generations there are in any given locality, they will give some clue to the time required for the development of a generation. Temperature conditions undoubtedly influence greatly the lengths of the various life periods.

HABITS.

Late in May or in the early part of June the over-wintering pupa makes a narrow slit in one end of the cocoon and exposes a small part of the anterior portion. The pupa case then splits and the moth emerges, the operation requiring from about 15 to 20 minutes. Sometimes the wings become their normal size in a short time, but in other cases 24 hours elapsed before the moth was perfect. The moths mate on the next day, or second day following. One pair under observation, having emerged on July 22, in the night, mated early July 23, and was observed in copulation from 7.30 until 11.30, a period of 4 hours. This was probably near the normal period, as the pair had not been out of the cocoon long. Oviposition usually follows soon after. In the pair mentioned above, one cluster of 69 eggs was deposited during the night of July 23. During oviposition, which took place early in the morning, or more often in the late afternoon or evening, the moth was observed to be on the underside of a leaf with the wings at right angles to the body. The abdomen was slightly bent, and the moth seemed to be depositing the eggs in rows. The period required for the oviposition of a cluster is several hours, depending upon the size of the cluster deposited. The flight of the moths appeared to be feeble, and they were sluggish, especially on cloudy days, the period of greatest activity being on clear days at midday. The length of life of the moth is from 2 to 5 days without food, although in the case of one pair under observation the male lived from 3 to 3½ days and the female from 6 to 6½ days.

The eggs are deposited on the underside of the leaf. Upon hatching, the larvæ start feeding from a common center, moving backward, and in a short time are side by side in a soldierlike formation, the feeding line usually being a curve. Although the larvæ may feed for a short time upon the lower surface, they are more frequently found upon the upper, as this is better adapted to their style of feeding—namely, skeletonizing or removing the outer epidermal layer of the leaf. This manner of feeding is usually followed until the larvæ reach the fifth instar, when some begin to eat holes through the leaf. From now on the larvæ gradually cease skeletonizing the leaf and eat the whole tissue, leaving only the larger veins.

Preparatory to molting, the larvæ crawl to the underside of the leaf and molt in a group, with their heads in the center. After molting they feed, moving backward, and gradually form a curved line. This was observed a number of times, although the larvæ had been feeding before in different groups on the upper surface of different leaves.

When the larvæ are full grown they seek some secluded place in which to pupate, usually spinning their cocoons on fallen leaves or in trash around the vine, or, when confined, to the sides of the cage. The period covered by one group of larvæ in spinning their cocoons will vary from 1 to 2 weeks, although the time required for the formation of each individual is not more than 2 or 3 days.

The winter is passed in the cocoon, the insect being in the pupal stage.

IDENTITY.

The slight variation in appearance of the moths and the differently marked larvæ bring up the question of identity. Dyar[a] thinks there is little difference between the moths of *Harrisana americana* and those of *H. texana* which Stretch separated by the presence of another vein, because moths of both kinds were taken together in the same locality. He found, however, two kinds of larvæ, those of *H. texana* having the dorsum of joints 2–13 broadly bright-yellow, and banded between each joint with blackish and again across the middle of each, including the warts, with purple-brown. The larvæ of *Harrisana australis* were similar to those of *H. texana*. He further says, "If it were not for the two kinds of larvæ, I would not hold these three forms separate." Credit is due to Dr. H. G. Dyar, of this Bureau, for examining all of the material in the Bureau collection and for determining it all as belonging to one species, *Harrisana americana* Guér.

NATURAL ENEMIES.

Up to the present time only one parasite had been recorded from this insect, namely, the chalcidid *Perilampus platygaster* Say, which Riley mentions as being a parasite of the larva. This summer, however, the writer reared a little hymenopterous parasite which was determined by Mr. J. C. Crawford, of the U. S. National Museum, as a braconid, *Glyptapanteles* sp., and also an inchneumon, *Limneria* sp., which was reared from larvæ sent in by C. M. Streeter, Dalton, Pa.

REMEDIES.

While the insect has never proved a serious pest in large vineyards, and is usually more troublesome in gardens or back yards where there are only a few vines, it has been found sufficiently numerous at times to demand attention and remedial measures.

The gregarious feeding habit of the larvæ makes hand-picking in small areas the most efficient treatment, as one person can go over a large number of vines in a short time and destroy a very large number of the larvæ, since they will be found in large groups upon the leaves. This should be done as soon as the larvæ are noticed upon the foliage, as all from each cluster of eggs will then be in a single group, whereas, if the treatment be deferred until the larvæ have separated into individuals or small groups, as mentioned before in this paper, much more labor will be involved.

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[a] Proceedings of the Entomological Society of Washington, Vol. V, p. 326.

An arsenical treatment, applied as soon as the larvæ are in evidence, would prove effective. Two applications are necessary, one for each generation of the larvæ. The time of application will vary greatly, being early in the South and becoming later in northern States, according to the time the larvæ appear upon the grapes, which is the best standard for determining when the treatment should be applied.

The arsenical used may be either arsenate of lead, Paris green, or arsenite of lime. Arsenate of lead is preferred on account of its better sticking qualities, and also because it is less likely to injure the foliage. Three pounds of any good brand of the latter added to the ordinary Bordeaux mixture (5–5–50 formula) will make a very efficient remedy.

Since the larvæ spin their cocoons in the leaves and trash at the bottom of the vines, clean culture is to be recommended. Where clean culture is followed, and where spraying is practiced for the grape-berry moth, grape root-worm, and grape curculio, this insect need never be feared.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 68, Part IX.

L. O. HOWARD, Entomologist and Chief of Bureau.

PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE PEACH-TREE BARKBEETLE.

BY

H. F. WILSON,

Engaged in Deciduous Fruit Insect Investigations.

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PAPERS ON DECIDUOUS FRUIT INSECTS AND INSECTICIDES.

THE PEACH-TREE BARKBEETLE.

(*Phlœotribus liminaris* Harr.)

By H. F. Wilson,
Engaged in Deciduous Fruit Insect Investigations.

INTRODUCTION.

By way of introduction it is perhaps necessary to give an account of the present degree of importance, from an economic standpoint, which this beetle has reached in northern Ohio. For the last four or five years this insect has been doing a great amount of injury to apparently healthy trees. The history of Scolytidæ in general shows that certain species may be present in orchards for years without doing any appreciable damage. Then, owing to favorable climatic or other conditions, they may develop in large numbers and accomplish considerable injury. Such seems to be the history of *Phlœotribus liminaris.*

The attention of Prof. H. A. Gossard, of the Ohio Agricultural Experiment Station, was called to this insect by Mr. W. H. Wright, in charge of a large farm at Lakeside, Ohio, Mr. Wright having reported to him that large blocks of peach trees in the orchard were dying from an unknown cause. Upon investigation Professor Gossard found that this orchard was seriously infested with *Phlœotribus liminaris.*

At the instance of Professor Gossard, investigation of this species was undertaken in the spring of 1908 by the Bureau of Entomology in cooperation with the Ohio Agricultural Experiment Station, and the writer, representing the Bureau, and working under the joint direction of Professors Gossard and Quaintance, was assigned to the work, with headquarters at Lakeside, Ohio. Through the courtesy of Mr. Wright a suitable building and experimental orchards were secured. All breeding cages were kept under out-of-door conditions, and as far as possible outside conditions were watched in comparison with those in the breeding cages. Data were secured on all stages of development of the insect, and the results obtained are considered fairly complete for a single season's work.

In all, 43 experiments with remedial and preventive measures were conducted during the summer, results of which are given herein. Field observations in this locality seemed to show that apparently healthy trees are attacked and, although the beetles probably do not form egg burrows in these, the loss of sap from the burrows made by the adults in the bark is sufficient to cause the trees to become very much weakened.

HISTORY.

The first published notes on this insect were made by Miss M. H. Morris, about 1849–50. At that time Miss Morris credited *Tomicus liminaris* as being the cause of "peach yellows," and so expressed her belief in several articles published in different magazines of that time, stating that the beetles were quite numerous about peach trees suffering from "peach yellows." These suggestions made by Miss Morris probably led Harris to include the insect in his treatise on "The Insects Injurious to Vegetation," published in 1852, where he briefly describes it under the name *Tomicus liminaris*, this later being changed to *Phlœotribus liminaris*. The following extract gives his description:

> There is another small barkbeetle, the *Tomicus liminaris* of my catalogue, which has been found in great numbers by Miss Morris under the bark of peach trees affected with the disease called the "yellows" and hence supposed by her to be connected with this malady. I have found it under the bark of a diseased elm, but have nothing more to offer from my own observations concerning its history, except that it completes its transformations in August and September. It is of a dark-brown color, the thorax all punctured, and the wing covers are marked with deeply punctured furrows and are beset with short hairs. It does not average one-tenth of an inch in length.

The beetle spoken of above as working in elm bark was later found by Mr. E. A. Schwarz, of this Bureau, to be *Hylesinus opaculus* Lec., he having examined the specimens used by Harris and named it the elm barkbeetle.[a] (This specimen, in Mr. Harris's collection, was called *Tomicus liminaris* and catalogued as such, as is shown by copies, taken by Doctor Hopkins, of the original notes.)[b]

For many years this insect did not become sufficiently important to demand special study, either of its life history or for the determination of remedial measures. Reference to this species has been made at different times, as in the annual reports of the entomologist of the Canadian experimental farms, and by entomologists in the

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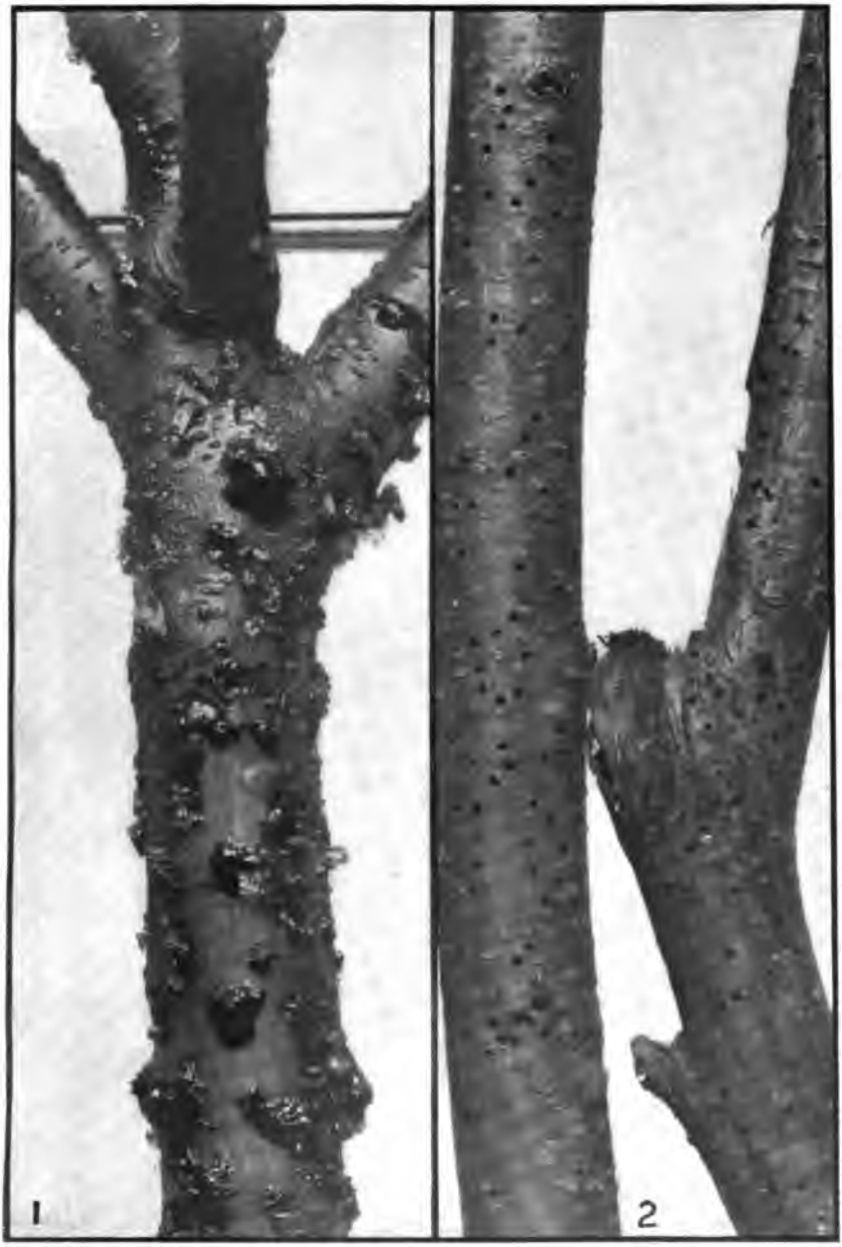
[a] Attention is here called to Mr. Schwarz's article on p. 149, Vol. I, No. 3, Proceedings of the Entomological Society of Washington (1889), on *Hylesinus opaculus*.

[b] The genus *Phlœotribus* is being revised by Doctor Hopkins, who will discuss the synonymy and other systematic features in a bulletin of the technical series of this Bureau.



WORK OF THE PEACH-TREE BARKBEETLE (PHLŒOTRIBUS LIMINARIS).

Fig. 1.—Gum exuding through burrows made in bark of peach tree. **Fig. 2.**—Exit holes in bark of peach tree. (Original.)

United States; and more recently experiments have been carried out by the Ontario experiment station in the district of Niagara. In looking over the past literature it is noticed that the injury done by the beetle has increased materially with the increased planting of peach and cherry, and the species has thus become one of economic importance.

Until the present season (1908) few direct measures had been taken to combat this barkbeetle, and very little, if anything, was known concerning its life history. Not until recently has it become very injurious to fruit trees, and these are limited to peach, cherry, and wild cherry. The beetles will, however, work on plum trees when confined to that food. So far but three localities have been reported as being visited with injury to any great extent, these being in the fruit district lying about Lakeside and Gypsum, Ohio; in the vicinity of Cayuga Lake, New York, and in the Niagara district, Ontario Province, Canada. The effects of the beetles' work are very serious in all trees attacked.

The peach-tree barkbeetle is a native of this country, and until cultivated trees were introduced must have held to forest trees for food and breeding places.. The work of the beetle is similar to that of the fruit-tree barkbeetle (*Scolytus rugulosus* Ratz.), and there exists a marked similarity in the beetles themselves by which the two species may be easily confused.

DISTRIBUTION.

Observations and reports show the distribution, in so far as known, to be as follows: New York, Pennsylvania, Maryland, Virginia, West Virginia, Ohio, and Michigan, and from the Niagara district, Ontario Province, Canada. Field notes on this species, in the branch of forest insect investigations, Bureau of Entomology, taken by Doctor Hopkins and Mr. W. F. Fiske, indicate that the species is found throughout almost all of West Virginia, and that it occurs in North Carolina and New Hampshire.

OCCURRENCE IN OHIO.

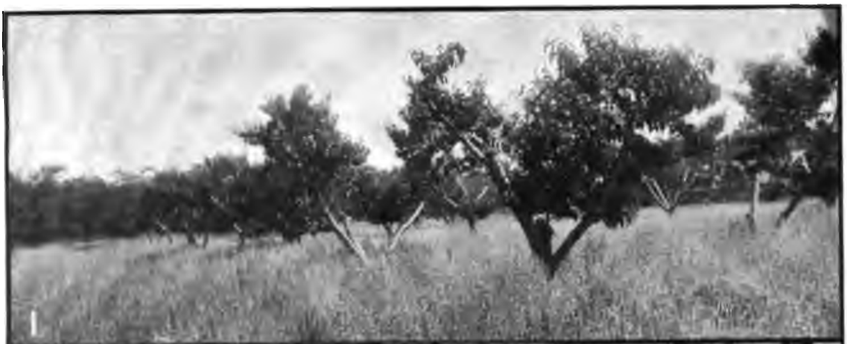
The date of the first appearance of this insect in Ohio is in question, as it has undoubtedly been in the State for some time, although it has not done any great amount of damage until recently. Some of the orchardists stated that they had seen its work for eight or ten years, but did not know the cause. An area of about 8 or 10 miles square about Lakeside, Ohio, including the adjacent islands, is badly infested. Outside of this locality the beetles occur east and west to a slight degree; and as the beetles have been taken at Youngstown, Ohio, and are reported from West Virginia and Michigan, it is very probable that this species is at present more or less generally distributed throughout the State.

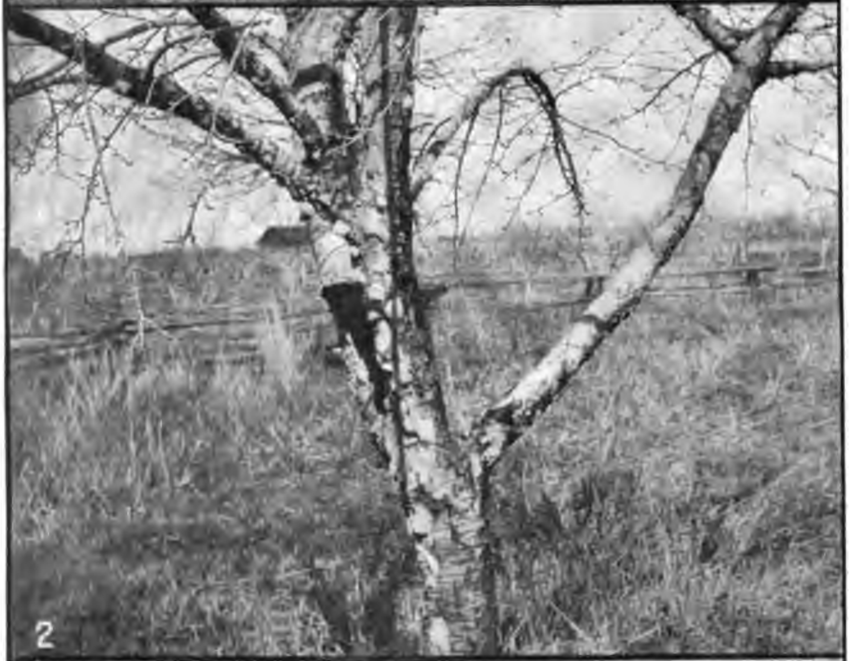
At Lakeside a lime manufacturing company bought up most of the land comprising the peninsula for commercial purposes. On this land are many remnants of orchards, which are uncultivated and uncared for, and are attacked by scale and numerous other insects. These trees are gradually being destroyed by the insects and are seriously attacked by *Phlœotribus liminaris*. Pieces of bark 2 to 3 feet long and extending half way around the trunk will be completely cut from a tree 8 inches in diameter by the larvæ. The dead trees in these orchards were uninfested when observed, but the bark was full of exit holes and the trees were girdled. (See Pl. XI, fig. 2.) Until these infested trees are all killed they will afford ideal breeding places for the beetles while they attack the near-by orchards in large numbers, either for food or in efforts to make egg burrows. These abandoned orchards undoubtedly have much to do with the large number of beetles present in this locality. Plate XI, figure 1, shows a view of one of these orchards which was cut back for the purpose of renovation. The result was that the trees developed a strong growth and were almost free from attack at the end of the season.

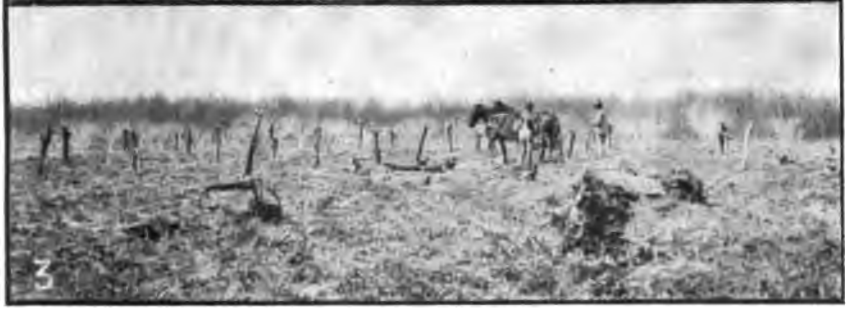
The reasons for the attack by beetles on apparently healthy trees, while important to know, can not yet be explained. Several orchards were observed where the beetles were attacking the trees in numbers without forming egg burrows. These orchards had borne crops continuously each year, but appeared to be becoming gradually weaker each season, and large quantities of sap oozed out and collected at the base of the trees during the summer months. In one case in which an orchard had been very badly injured, whitewashing the trees was tried, and the present season (1908) the trees appear healthy and thrifty with but few beetles present, these having worked into the smaller branches above the whitewash.

EXTENT AND CHARACTER OF INJURY.

When the beetles are present in large numbers their injury to the trees is quickly brought to the attention of the orchardist by the large amount of sap exuding from the trees through the many small borings made both in the trunk and limbs of the tree. (See Pl. X, fig. 1.) In some instances from 1 to 3 or more gallons of sap will flow from a single tree during a season. The writer observed one wild-cherry







WORK OF THE PEACH-TREE BARKBEETLE (PHLŒOTRIBUS LIMINARIS).

Fig. 1.—Orchard severely pruned April 19, 1908. Photograph taken July 7, 1908. **Fig. 2.**—Gum exuding through burrows made in bark of cherry tree. **Fig. 3.**—Removing stumps of trees supposed to have been killed by the barkbeetle. (Original.)

tree about 14 inches in diameter and from 75 to 80 feet high which had apparently been killed by the beetles, the bark having been completely eaten away from the tree.

The adults or beetles (see fig. 20, *a*, *b*) produce the primary injury to healthy trees, the work of the larvæ being secondary. The healthy trees, by repeated attacks of the adults, are reduced to a condition favorable to the formation of egg burrows. When the beetles are ready to hibernate in the fall they fly to the healthy trees and form their hibernation cells. These latter are injurious to the trees, for through each cell there will be a tiny flow of sap during the following season. (See Pl. XI, fig. 2.)

The greater the number of hibernation cells, the greater will be the amount of sap exuded; also, when the beetles come out of their winter quarters in the spring they bore into the bark of healthy trees from one-quarter to one-half of an inch, either for food or in an endeavor to form egg burrows. Later the beetles leave these burrows, either because the burrows become filled with sap or because the beetles seek the sickly trees for breeding purposes. Many more small channels are thus formed in the bark and from these sap oozes during the summer. Two means are therefore supplied by which the sap may flow from the trees—and this it does in many cases, forming large gummy masses around the trunks. Such losses for three or four years in succession necessarily reduce the trees to a very much weakened condition, and it then becomes possible for the beetles to form egg burrows and for the larvæ to finish the destruction of the tree. Plate XI, figure 3, shows the remains of an orchard presumably killed by *Phlœotribus liminaris*.

LIFE HISTORY.

HIBERNATION.

The insects spend the winter as adults in hibernation cells just beneath the outer layer of bark on both healthy and unhealthy trees. In the fall, from October to freezing weather, the adults of the fall generation are continually emerging and migrating to growing trees. They bore in through rough places on the bark and burrow along from one-quarter to five-eighths of an inch, forming hibernation cells, the openings to which are closed with the exudation from the burrow. In these cells they remain throughout the winter. The latest formed adults of the fall brood remain in the pupal cells until spring before cutting out, so that hibernation occurs both on dead and living trees, those on the live trees hibernating in regular hibernating cells and those on dead trees hibernating in the pupal cells.

With the first warm weather in spring—as early as the last of March in the latitude of Lakeside, Ohio—the beetles begin cutting their way out from their hibernation cells. They do not immediately leave these, but remain from four days to a week or more, most of them feeding for a while and then migrating to trees, wood piles, and brush heaps, or to anything upon which they can feed and in which make brood chambers.

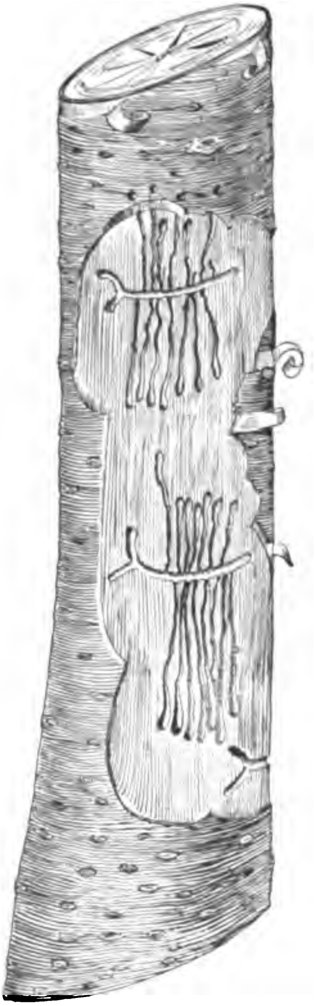


FIG. 18.—Work of the peach-tree barkbeetle (*Phlœotribus liminaris*): Galleries in limb of peach tree, November 20, 1908. (Original.)

THE ADULT.

HABITS.

The beetles fly but little during the morning hours, migrating from tree to tree for the most part between the hours of noon and night. During the day the beetles move about on the trees, the females seeking places in which to burrow and the males searching for burrows already started in which the usually accompanying male is lacking. After nightfall flight and movement over the tree cease.

The male beetles probably commence feeding as soon as they cut their way out of the pupal cell, and continue to feed more or less as long as they live. When in the brood chamber they excrete a brown bead-like frass, the food for this sex evidently being cut loose and passed back by the female. The female commences feeding as soon as she has cut into the edge of the bark, and feeds until she is too feeble to form egg cells.

The burrows of *Phlœotribus liminaris* can be very easily distinguished from those of *Scolytus rugulosus*, both from the outside and on the inside of the bark. The opening of the burrow of the former is very easily distinguished from the fact that the exudation from the burrow is held together by a fine, apparently silklike thread, which is secreted by both male and female. This holds the exudation over and partly in the mouth of the burrow. After going into the sapwood the female constructs a niche which later forms an arm of the egg burrow. While an extension opposite this is being made the males copulate with the females at this point. At other times the males remain between the mouth of the burrow and this niche, occasionally going deeper into the burrow. Copulation ordinarily takes place at the fork in the burrow, and has been observed a number of times to last as long as fifteen minutes after the cutting away of the bark. The female rests with the posterior end of the abdomen just at the edge of the fork, the male operating from the adjoining niche. The sole function of the male seems to be that of attending the female, as none has ever been observed working.

The forks of the burrow may or may not be nearly equal in length, but usually they vary to quite an extent. They are, however, always more or less horizontal, running around the axis of the limb. (See figs. 18 and 19.) After being fertilized the female immediately sets about depositing eggs, and at this time the abdomen is very much swollen. During the construction of the burrow copulation occurs several times, so that the length of the burrow appears to depend upon the number of times of copulation. As soon as the egg is deposited the female covers it with frass, so that the main burrow is a circular tube of sawdust, outside of which occur the eggs. The method of egg deposition is as follows:

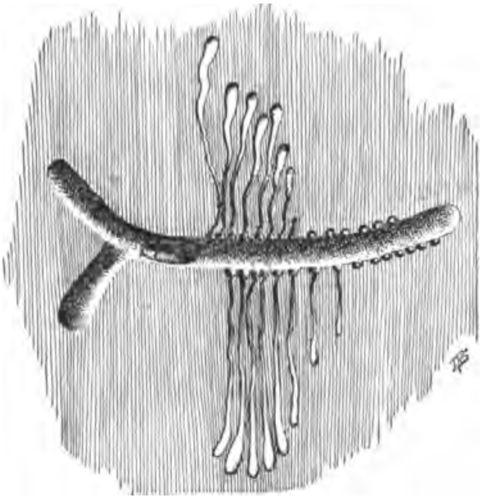


FIG. 19.—Work of the peach-tree barkbeetle (*Phlœotribus liminaris*): Galleries in wood of peach tree, May 18, 1908, Lakeside, Ohio. Enlarged. (Original.)

Having made the egg cell, the female backs out to the niche where, after turning around, she backs into the cell again, clinging to the side of the burrow. The egg is then placed in the cell, and after again turning around the female covers it with the sawdustlike frass. The egg cells are filled as soon as they are finished, and each is made as soon as the burrow has been extended far enough to make room for it.

From ten days to two weeks are necessary for the completion of the burrows. The males and females in the same burrow live until after most of the larvæ have developed into the next brood of beetles. The completed burrows of this species are more nearly equal in length than those of *Scolytus rugulosus*, the maximum length being about $2\frac{5}{8}$ inches, with an average of $2\frac{1}{16}$ inches.

There are two complete broods each year—the summer brood and the fall brood, the latter being the hibernating one, the beetles appearing in early spring. Beetles of the summer brood appear in maximum numbers during the last half of August, as shown more in detail in the following table:

Table I.—*Emergence of summer brood of beetles of Phlœotribus liminaris.*

Date.[a]	Beetles reared in cages.	Beetles from insectary on window screens.	Date.[a]	Beetles reared in cages.	Beetles from insectary on window screens.
July 16	2	60	Aug. 25	40	...
23	...	30	26	60	1,500
24	...	74	27	86	1,000
26	83	...	28	69	600
27	...	300	29	72	1,000
28	82	...	Sept. 3	154	200
29	30	...	4	111	...
31	82	450	5	40	200
Aug. 4	68	...	7	67	75
5	...	350	10	18	...
6	84	500	11	38	...
9	151	...	13	91	40
12	258	450	15	37	...
15	...	1,200	17	29	...
16	...	750	19	12	...
17	...	750	22	32	...
18	317	1,750	24	21	...
[b] 21	327	2,500	29	7	...
24	129	...	Oct. 2	4	...

[a] The first column shows beetles actually counted and taken from a breeding cage; the second row of figures shows, somewhat estimated, numbers of beetles gathered on screens at windows. All counts made between 4 and 6 p. m.

[b] This table shows August 21 to be the date of maximum emergence of beetles.

DESCRIPTION.

Average length, 2.25 mm., average width, 0.75 mm. Body elongate, subcylindrical, strongly punctured and with yellowish bristles arising from the punctures; color varying from light brown to almost black. Head globular, nearly vertical in front, anterior part fringed; eyes narrowly oblong, closely joined to the scape and extending about half their length below it; mandibles short and broad, distal part curved and strongly acute; mouth parts partly inclosed, gular suture distinct; funiculus of antennæ five-jointed; club compressed, composed of 3 triangular segments; first joint longer than wide, globular; scape circular, clavate. Thorax almost cylindrical, strongly angled at caudal end. First and second coxæ widely separated, globular; femur stout, outer edge serrated; tibia stout, compressed, lower half of outer edge serrated and ending in an apical tooth; tarsus stout, shorter than tibia, third joint bilobed, fourth indistinct, fifth as long as first and second together; tarsal claws simple. Ventral side of abdomen and posterior edge of last segment strongly concave; elytra anteriorly rounded and deeply margined, sides parallel, surface with regular striæ which contain circular, regularly placed depressions, elevated parts with yellowish bristles arising from faint punctures.

THE EGG.

The eggs of the first generation may be found about the third week in April, and, from that time on, the eggs of the first and second generation can not be separated, owing to the irregular emergence of beetles and the irregular forming of egg burrows. Eggs can be found in all stages of development up to the first week in October. The eggs of the second generation begin to appear about August 1.

Owing to the small series of eggs observed, the following data on length of the egg stage are not given as conclusive: Eggs of the first generation require from 17 to 20 days to hatch, while the eggs of the second generation hatch in about 8 to 10 days. The egg (fig. 20, *c*) is milky white when first deposited, being elliptical in shape, opaque, and measuring 0.06 mm. in length by 0.0385 mm. in diameter. The eggshell is fairly tough and the eggs may be very easily taken out of the egg cells. When working without interruption the female deposits from 2 to 10 eggs each day, in addition to making the cells.

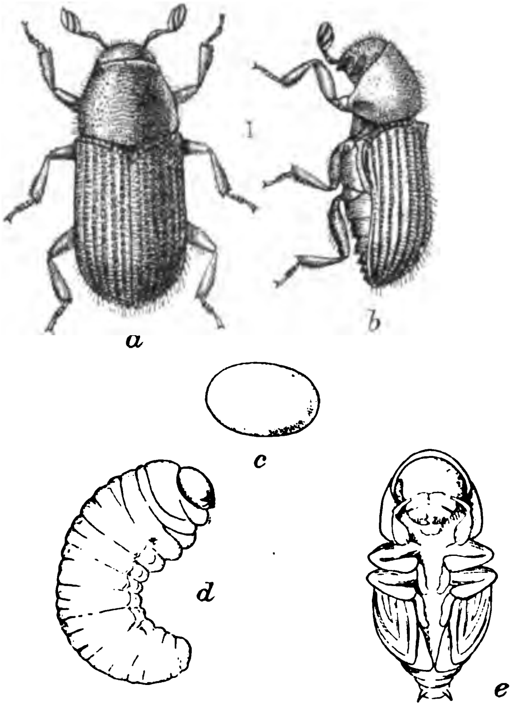


FIG. 20.—The peach-tree barkbeetle (*Phlœotribus liminaris*): *a*, *b*, Adult, dorsal and lateral views; *c*, egg; *d*, larva; *e*, pupa. Greatly enlarged. (Original.)

The number of eggs in egg burrows of this species varies, since the eggs are not always deposited at equal intervals. Each brood chamber may contain between 80 and 160 eggs. In the vicinity of Lakeside, Ohio, eggs can be found from April 20 until October 1. The egg burrow is not always made next to the sapwood, as in a tree where the bark is very thick the chambers are formed in the latter about one-fourth of an inch from its outer edge.

THE LARVA.

When the embryonic larva has become fully developed it lies in a curved position in the shell. After moving about a short time it eats its way out at or just above the bottom of the egg and begins to feed along the under surface of the bark. When first hatched the larvæ are slightly longer than the egg but are less in diameter. After emerging from the eggshell they are found lying in a slightly curved position in the larval burrows. At first they are white but soon assume a pinkish tinge due to the bark in the digestive tube. The larvæ at first feed slowly and are several days getting away from the eggshell but progress faster as they grow larger. As they work out of the eggshell the sawdustlike excrement passed through the body fills these and holds them in place as the larvæ work out. The excrement voided by the larvæ marks their path, appearing like very fine sawdust.

The larvæ work away from the brood chambers at right angles, following, for the most part, the grain of the wood. For from one-half to three-fourths of an inch the larval burrows lie side by side, but later they diverge, so that the exit holes (Pl. X, fig. 2) form an irregular ellipse around the brood chamber. The larval burrows measure from 1½ to 2⅞ inches in length. When about to pupate in bark, which is about one-eighth of an inch or more in thickness, the larvæ work toward the outer edge of the bark and there form pupal cells. In these cells the larvæ continue to develop from one to three or more days before casting the skin and becoming pupæ.

Some 25 to 30 days are required for the full development of the larvæ. At the end of this time, having finished feeding, they void the excrement before pupating and have then a white appearance. Through the life of the larvæ the head is covered with a fine yellowish pubescence, which is more abundant about the mouth parts than elsewhere. (Full-grown larva, fig. 20, *d*.)

Description of full-grown larva.—Length, 2.15–2.75 mm.; width across thorax (widest part of insect), about 1.16 mm. Head subelliptical, about 0.6 mm. wide, yellowish, apex lighter; mandibles brownish, dark at tip. Body white, curved, tapering from thorax to rounded caudal end, quite wrinkled; legless, but on ventral surface of thoracic segments a small group of setæ at points of position of the adult's legs. Head with a few sparse setæ and a few on body. Body covered all over with many minute, short, stout spines.

THE PUPA.

The pupæ (fig. 20, *e*) are quite active, moving the abdomen continually back and forth. From 4 to 10 days are spent in the pupal stage, the pupa gradually assuming a dark color. When the pupal skin is cast, the beetles are very tender; they require from 4 to 6 days to completely harden and usually do not cut their way out from the pupal cells until they have fed a little, after which they remain in the pupal cells for from several days to two weeks longer.

Description of pupa about 3 days old.—Length, 2.5–2.66 mm.; width at widest part, 1.08–1.11 mm. Body uniformly white, except along sides of abdomen, which may show faint yellowish tinge. Eyes reddish brown; mouth parts (interior) faintly brownish. Abdomen ending in two lateral, whitish, minutely spinulose, brown-tipped horns.

PARASITES.

At the present date (December, 1908) no parasites of this species are known. Where *Scolytus rugulosus* and *Phlœotribus liminaris* bred in the same trees the usual parasites of *S. rugulosus* were found in great abundance, with a corresponding decrease in the number of adult *S. rugulosus*, while *P. liminaris* came out in numbers corresponding to the larval chambers. Efforts were made to rear the parasites upon limbs full of *P. liminaris*, but without success. Many minute mites—which, however, are not parasites—are found in and about the burrows and clinging to the hairs about the legs of the beetles and the ventral side of the thorax. They live on the excrement of the beetles and decayed matter in the burrows, simply using the adult beetles for the purpose of being carried from one place to another.

EXPERIMENTS WITH REMEDIES.

A list of the general experiments and a summary of the results is given below. Each experiment was made on a plat containing the number of trees mentioned.

No. 1.—Used 16 trees. One part by weight of lime; 2 parts by weight of cement; milk used to make a stiff whitewash and applied with a broom to 96 trees, 32 of which were used in experiment No. 2, with the addition of manure. Thirty-two more were used for experiment No. 3, with an application of commercial fertilizer. Sixteen trees of each plat were given a second application, forming experiments Nos. 4, 5, and 6.

Date of application, April 9, 1908.

No. 2.—Used 32 trees of experiment 1. Barnyard manure spread in a 7-foot circle about each tree, to get value of fertilizers.

Date of application, April 9, 1908.

No. 3.—Used 32 trees of experiment 1. Commercial fertilizer applied in a 7-foot circle about each tree.

Cement applied April 9, 1908; fertilizer applied May 7, 1908.

No. 4.—Used 16 trees of experiment 1, making a second application.

First application, April 9, 1908; second application, July 3, 1908.

No. 5.—Used 16 trees of experiment 2, making a second application.

First application, April 9, 1908; second application, July 7, 1908.

No. 6.—Used 16 trees of experiment 3, making a second application.

First application, cement, April 9, 1908; fertilizer, May 7, 1908. Second application, July 3, 1908.

No. 7.—Used 2 pounds fish-oil soap per gallon of water (dissolving soap in boiling water) for first application. Used 1 pound of soap to 6 gallons of water for second treatment. Twenty-four trees treated, 16 to be used for experiments 8 and 9.

First application, April 10, 1908; second application, July 7, 1908.

No. 8.—To each of 8 of the 24 trees treated in experiment 7 added barnyard manure to find value of fertilizers.

First application, April 10, 1908; second application, July 7, 1908.

No. 9.—To remaining 8 trees of experiment 7 added commercial fertilizer, 4 pounds to each tree, spreading in a 7-foot circle.

Fertilizer added May 7, 1908; second application, July 7, 1908.

No. 10.—One gallon carbolineum mixed with 20 pounds of flour, then 25 gallons water added to make emulsion; sprayed 72 trees, 48 of which were used for experiments 11 and 12 to get value of fertilizers.

Sprayed whole tree April 10, 1908; sprayed trunks and limbs below foliage July 6, 1908.

No. 11.—Used 24 trees of experiment 10, and added barnyard manure, spreading it about tree in 7-foot circle.

First application, April 10, 1908; second application, July 7, 1908.

No. 12.—Used 24 trees of experiment 10, and added 4 pounds of commercial fertilizer to each tree, spreading it in 7-foot circle about tree and harrowing in.

First application, April 10, 1908; second application (3 pounds commercial fertilizer), July 6, 1908.

No. 13.—Used 1 gallon carbolineum, emulsifying it with 4 pounds soap (dissolved in 4 gallons of water), and diluting the whole to 8 gallons; sprayed 144 trees, 96 of these to be used in four more experiments.

Application made April 10, 1908.

No. 14.—Used 48 trees of plat 13. Sprayed twice.

First application, April 10, 1908; second application, July 6, 1908.

No. 15.—This was to have been a third spraying, but was found unnecessary on account of absence of beetles.

No. 16.—Used 24 trees of experiment 13. Barnyard manure (to get value of fertilizers) spread about trees in a 7-foot circle.

First application, April 10, 1908; second application, July 6, 1908.

No. 17.—Used 24 trees of experiment 13. Commercial fertilizer added, 4 pounds to each tree, spread in a 7-foot circle to get value of fertilizer.

First application, April 9, 1908; second application, July 3, 1908 (3 pounds fertilizer).

No. 18.—Sprayed 6 trees with pure carbolineum without seeming injury to the trees.

Application made April 9, 1908.

No. 19.—Used 25 pounds of lime, 15 pounds sulphur, 6 pounds resin, 3 pounds arsenate of lead, and 50 gallons of water. Applied the mixture with a brush to trunks and large limbs of 6 trees.

Application made April 17, 1908.

No. 20.—Same as experiment 19, plus barnyard manure. Two of 6 trees in experiment 19 used.

Application made April 17, 1908.

No. 21.—Same as experiment 19, plus commercial fertilizer. Two of 6 trees in experiment 19 used.

Application made April 17, 1908.

No. 22.—One gallon carbolineum, 1 gallon lard, and 25 pounds resin. Painted trunks and larger limbs of 5 trees.

Application made April 17, 1908.

No. 23.—One bushel tobacco stems boiled for one hour in 4 gallons of water; one-half bushel stone lime and 4 quarts salt added; one-half pint crude carbolic acid used in each 12 quarts of the liquid. All gum and rough bark scraped from the trees and the paint put on with a broom.

Applied the mixture to 72 trees April 22, 1908.

No. 24.—Used 24 trees of experiment 23. Same treatment, plus barnyard manure spread in 7-foot circle about each tree.

Application made April 22, 1908.

No. 25.—Used 24 trees of experiment 23, plus commercial fertilizer spread in 7-foot circle about each tree.

Applied April 22, 1908; fertilizer applied May 7, 1908.

No. 26.—One gallon chloronaptholeum, emulsified with 4 pounds of soap (dissolved in 4 gallons of water); then added water enough to dilute to 25 gallons. Sprayed 120 trees.

First application, April 22, 1908; second application, July 7, 1908.

No. 27.—Used 24 trees of experiment 26; added barnyard manure, spreading it in a 7-foot circle about each tree.

First application, April 22, 1908; second application, July 7, 1908.

No. 28.—Used 24 trees of experiment 26, adding commercial fertilizer, 4 pounds to each tree, spreading it in a 7-foot circle.

First application, April 22, 1908; fertilizer added May 7, 1908; second application, July 7, 1908 (3 pounds fertilizer added).

No. 29.—One gallon chloronaptholeum mixed with 22 pounds flour to emulsify, added to 30 gallons water, and put on 120 trees with spray pump.

First application, April 17, 1908; second application, July 13, 1908.

No. 30.—Used 24 trees of experiment 29; added barnyard manure to get value of fertilizer.

First application, April 17, 1908; second application, July 13, 1908.

No. 31.—Used 24 trees of experiment 29, adding commercial fertilizer, 4 pounds, to each tree.

First application, April 17, 1908; fertilizer added May 7, 1908; second application, July 13, 1908.

No. 32.—Six pounds arsenate of lead to 50 gallons water; 3 pounds lime added to neutralize the free arsenic. Put on heavy spray; pruned trees before spraying; 170 trees sprayed.

First application, April 20, 1908; second application, July 13, 1908.

No. 33.—Boiled lime and sulphur spray (15 pounds lime, 15 pounds sulphur, 50 gallons water). Excessive application made to 200 trees.

First application, April 24, 1908; second application, July 13, 1908.

No. 34.—Self-boiled lime-sulphur wash (15 pounds lime, 10 pounds sulphur, 50 gallons water). Water added slowly so as to prevent burning, stirring vigorously during the process. Sprayed 300 trees.

First application, May 18, 1908; second application, July 13, 1908, to trunks and larger limbs.

No. 35.—A stock solution of kerosene emulsion, 20 per cent strength, was made and to each gallon of stock solution 2½ gallons rain water were added. Applied with spray pump.

Application made April 20, 1908.

No. 36.—Fumigated 6 trees with hydrocyanic-acid gas for one hour, first scraping off all gum and rough bark. Treatment given August 24, 1908.

No. 37.—Tree tanglefoot. Put bands around 12 trees and then covered bands with tanglefoot. Application made April 25, 1908.

No. 38.—Renovation block. Pruned back severely about 100 trees (girdling 4 trees for traps and not treating them further); applied fertilizer twice and kept trees cultivated all summer.

First application, April 19, 1908; fertilizer added May 7, 1908 (4 pounds per tree). Second application, July 3, 1908 (3 pounds fertilizer added).

No. 39.—A duplicate of experiment 17 tried on 200 trees; pure whitewash was applied as a second treatment.

Emulsion applied April 21, 1908; whitewash applied September 1, 1908.

No. 40.—Placed pieces of branches as traps in trees of small orchard to see if beetles would settle on them.

No. 41.—One-half barrel kerosene emulsion used instead of water to make a good stiff whitewash, applying with broom to plat of 200 or 300 trees.

First application made May 4, 1908; second application, July 9, 1908.

No. 42.—One gallon of chloronaptholeum added to every barrel of whitewash used. Whitewash made as thick as possible and applied with a broom to plat of about 200 trees.

First application, May 6, 1908; second application, July 9, 1908.

No. 43.—One gallon of Avenarius carbolineum added to each barrel of whitewash used; whitewash made as thick as possible and applied with a broom to a plat of about 200 trees.

All fertilizer used in above experiments was of the following formula:

	Per cent.
Phosphoric acid	8
Nitrogen	5
Potash	2

All trees fertilized made a growth of rich green foliage and the trees looked healthy, yet many of them were again attacked by the beetles.

RESULTS OF EXPERIMENTS.

The first 6 experiments seem to show that whitewash acts as a repellent, not affecting the beetles once they are in the bark, but if the trees are kept well coated the beetles do not seem to attack the whitewashed parts. The addition of fertilizer to the trees causes a strong flow of sap which, exuding through the burrows, seems to repel the beetles. The treatments given in Nos. 7, 8, and 9 seemed to have no effect whatever. In experiments 10, 11, and 12 the beetles in the tree at the time of application appeared to be killed, but the mixture did not act as a repellent and beetles settled on the trees again in a short while. Experiments 13, 14, 15, 16, and 17 were more promising, and two applications a season would undoubtedly keep the beetles down. The expense of these experiments, however, makes them impracticable as tried here. In experiment No. 18 all beetles attacking the trees at the time of application were killed, and others did not settle on the trees during the entire season.

The cost of the materials used in this experiment, however, makes the treatment impracticable. Experiments 19, 20, and 21 had no effect whatever, neither killing the beetles in the trees nor repelling others. In experiment 22 all trees treated were killed. Experiments 23, 24, and 25 gave very good results, the whitewash sticking well and the beetles not attacking the trees until long after the whitewash had fallen off. Experiments 26, 27, and 28 seemed to have had very little effect on the beetles in the bark and did not repel later attacks. Experiments 29, 30, and 31 failed to give any beneficial results, the emulsion being very poor, as the oil became partly separated from the mixture before the latter could be applied. Experiments 32, 33, 34, 35, 36, and 37 gave only negative results, neither killing the beetles in the burrows nor repelling later attacks. In experiment 38 a plat of 100 trees was used. Fifty of the trees were very severely cut back and 4 or 5 of them, being too weak to recover, died. The other 50 trees were sprayed with lime-sulphur wash. At the end of the season the pruned trees had produced a strong, healthy foliage and the beetles were attacking them but little. The untrimmed trees were badly attacked and had thrown out a scant, sickly-looking foliage. Experiment 39 gave satisfactory results. All of the beetles in the trees at the time of application were killed and no more settled on them until about the last of September; then, a few having settled, the trees were whitewashed and further injury was stopped. The cost of this treatment, as made here, prevents it being practicable for a large orchard unless the amount of material used can be reduced with equally good results for the weaker emulsion. Experiment 40 showed that the beetles attack the trees in which these cut branches were placed without settling on the cut branches. Experiments 41, 42, and 43 showed the most practicable, and at this time the most likely remedies. These are the combinations of a whitewash and an oil, the whitewash probably being the main factor in repelling the beetles. The cost of these experiments was 1¼ cents per tree for each application. The trees in these plats, while not entirely free from further attack during the season, suffered considerably less than surrounding plats of trees.

METHODS OF CONTROL.

Pending further investigation, the following treatments are suggested as being practicable and to a certain degree favorable:

For trees seriously injured.—Severely trim back the trees and apply barnyard manure or commercial fertilizers; then apply a thick coat of whitewash three times a season, the first application to be made the last week in March, the second application during the second week in July, and the third application about the 1st of October.

For trees apparently healthy but slightly attacked.—Paint the trees with a thick coat of whitewash three times each season as in the previous treatment, applying it to the trunks and larger limbs. The whitewash applied at the times specified will act as a repellent, the emergence of the beetles being slightly later than the dates given for the different applications. Add one-fourth pound table salt to each pail of whitewash, thus making the latter more adhesive. All of the dead or nearly dead limbs and trees should be removed and burned as fast as they appear in an orchard, as this will destroy the breeding places.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 69.

L. O. HOWARD, **Entomologist and Chief of Bureau.**

THE CHINCH BUG.

BY

F. M. WEBSTER,

In Charge of Cereal and Forage-Plant Insect Investigations.

ISSUED JUNE 21, 1907.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., March 5, 1907.

Sir: I have the honor to transmit for publication the accompanying manuscript entitled "The Chinch Bug," by F. M. Webster, in charge of the cereal and forage-plant insect investigations of this Bureau. This is a thorough revision by Mr. Webster of his earlier account of this destructive pest published in 1898 as Bulletin No. 15, new series, of this office, and includes additional data based on observations made during the past eight or nine years. I recommend that it be published as Bulletin No. 69 of the Bureau of Entomology.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE CHINCH BUG.

Few insects, and certainly no other species of the natural order to which this one belongs, have caused such enormous pecuniary losses as has the chinch bug, *Blissus leucopterus* Say. No other insect native to the Western Hemisphere has spread its devastating hordes over a wider area of country with more fatal effects to the staple grains of North America than has this one. But for the extreme susceptibility of the very young to destruction by drenching rains and to the less though not insignificant destructiveness during rainy seasons of the parasitic fungus, *Sporotrichum globuliferum* Speg., on both the adults and young, the practice of raising grain year after year on the same areas, as followed in the United States, would become altogether unprofitable. Some of this insect's own habits, emphasizing as they do the effects of meteorological conditions, are the most potent influences that serve to hold it within bounds, by giving its tendency to excessive increase a decidedly spasmodic character.

DISTRIBUTION.

The genus Blissus is widely distributed over the world, occurring in South Africa, Abyssinia, Algeria, Sicilia, southern Europe, northward at least to the sand dunes of central and northern Hungary, India, Japan, southern Russia, and in the Western Hemisphere in Buenos Aires, and from Panama and the Island of St. Vincent northward to middle California on the Pacific coast and Cape Breton on the Atlantic. When we come to understand that the Hemiptera of the world are far from being well known, and the faunas of South America and central Africa have as yet been hardly studied at all, we may well presume that future studies of the hemipterous insects of these countries may unite some of the different areas now known to be inhabited by the several species of this genus.

At present in the Old World this genus may be said to occur in the Ethiopian, Oriental, and Palæarctic life regions; while in the New World it ranges from the Neotropical region at Panama and St. Vincent into the Nearctic over the borders of the Boreal subregion in British America.

Our American species, *Blissus leucopterus* Say, the only one of the genus at present known in the Western Hemisphere, has been recorded from St. Vincent and Grenada, West Indies, by Uhler; Cuba, by Stål;

Volcan de Chiriqui, Bugaba, and San Feliz, Panama, by Champion; San Geronimo, Paso Antonio, Panzos, Champerico, and Rio Naranjo, Guatemala, by Champion; Lower Purissima, Lower California, by Uhler; Alameda, Cal., by Koebele; and in the vicinity of San Francisco, Cal., by both Uhler and Koebele; Orizaba, Mexico, by H. H. Smith; Tamaulipas, Mexico, by Uhler; Mesilla Park, N. Mex., by Cockerell; Florida, by Schwarz and Dr. J. C. Neal; Sydney, Cape Breton, by W. H. Harrington; Muskoka, Ontario, Canada, by E. P. Van Duzee, and Winnipeg, Manitoba, where a single specimen was collected by Dr. James Fletcher and given by him to Mr. Harrington, to whom I am indebted for information regarding its occurrence. Inland, in the United States, it may be said to be generally distributed from Texas to Manitoba. It is also very probable that its occurrence along the Pacific coast is much more extended than is at present known, as it has not been searched for to any extent in that region. (See map, fig. 1.)

HIBERNATION.

The chinch bug hibernates in the adult stage, and though there may be occasional exceptions, especially in the South, it has yet to be observed in very early spring in any other than the adult stage, at least in any locality north of Mexico. The writer observed pupæ in central Illinois apparently in hibernation in company with adults on November 11, but there is no proof that these survived the succeeding winter. In Tensas Parish, La., adults were abroad in considerable numbers during March, 1887, yet there was no indication of any young having wintered over. The adults were pairing and seemingly engaged in oviposition, precisely as is to be observed in the Northern States during May and June. No young were observed, as most certainly would have been the case had they occurred there, for observations were made in fields of young corn, where, had the young bugs been present even in very limited numbers, they would certainly not have escaped the rigid searching under and about the bases of the leaves of the young corn plants.

Doctor Howard[a] quotes Prof. G. F. Atkinson, at that time of Chapel Hill, N. C., as having observed half-grown chinch bugs on crab grass, about the 1st of October. The same authority also quotes Doctor Riley to the effect that many of the chinch bugs pair in the fall preparatory to seeking winter quarters, and also cites the fact that Mr. James O. Alwood observed them pairing in a field of uncut pearl millet, October 27, 1887, on the grounds of the Ohio Agricultural Experiment Station, then at Columbus, Ohio. Dr. Cyrus Thomas,[b] in speaking of the possibilities of an occasional third brood in southern Illinois and Kentucky, states that there were some evidences of this, but not sufficient to justify him in asserting it as a fact or to satisfy him of its correctness.

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[a] The Chinch Bug, by L. O. Howard; Report of the Commissioner of Agriculture for the year 1887, pp. 51–88.

[b] Bulletin No. 5, U. S. Entomological Commission, p. 13.

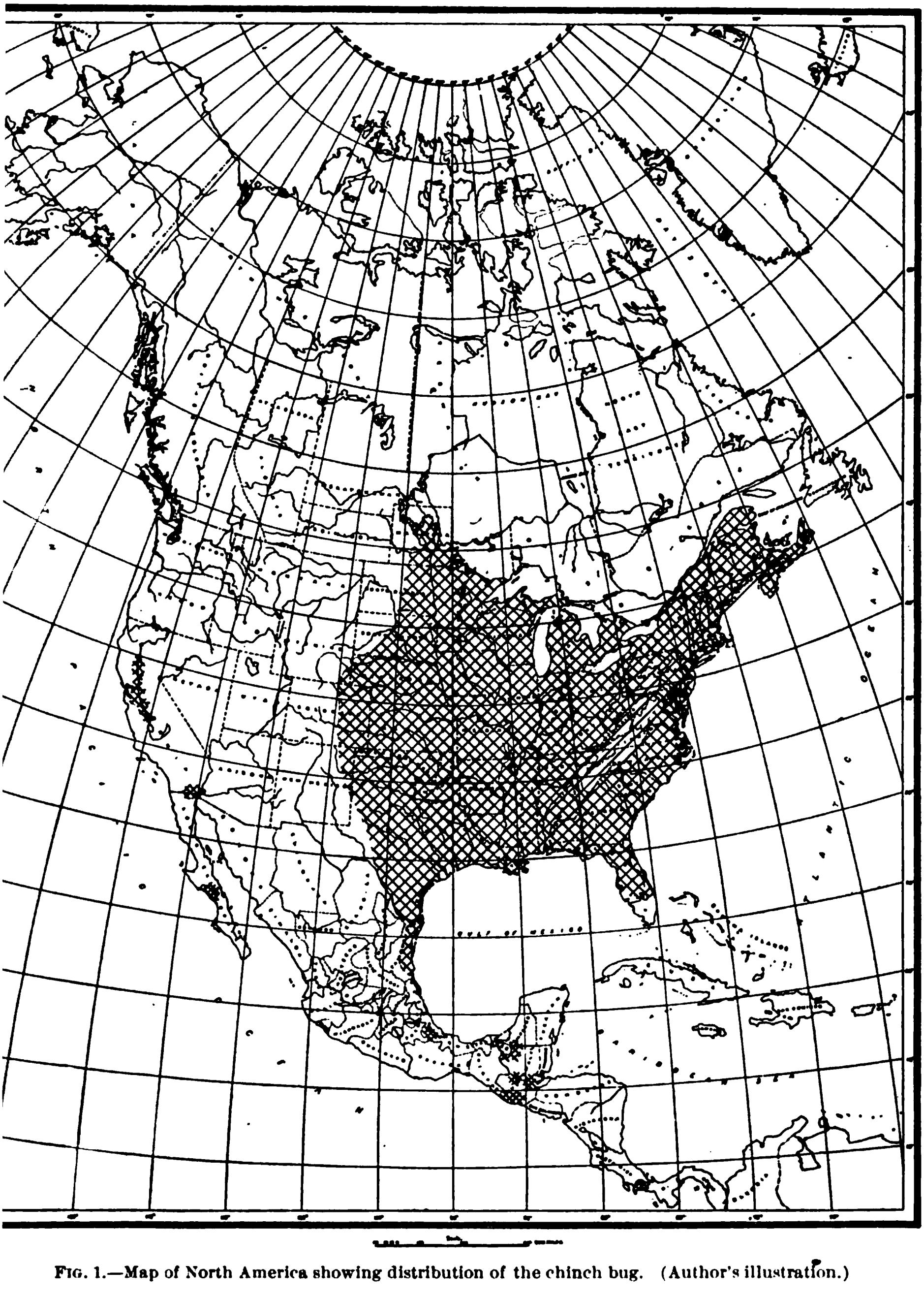

FIG. 1.—Map of North America showing distribution of the chinch bug. (Author's illustration.)

It therefore seems probable that no young are produced as a result of the late pairing, at least until spring, and it has yet to be shown that the late appearing larvæ do not mature before the hibernating season sets in, or else die during the winter. When we come to consider the extreme susceptibility of the newly hatched chinch bug to wet weather, less perhaps in case of the short-winged form, it will be apparent that as we approach the Tropics the wet and dry seasons would tend to influence the breeding seasons, as those individuals that hatched before the close of the rainy season would be, in a measure at least, continually eliminated, while those that hatched so late as to be caught in the commencement of the rainy season would also be to an equal extent destroyed, and thus, by continually restricting the breeding period to certain months, establish a fixed law that would be adhered to even under the somewhat different conditions which occur farther to the northward. Unfortunately the date or dates on which the young were observed by Mr. Champion, on Volcan de Chiriqui, in Panama, are unknown to the writer, and it is impossible to say whether or not they were found during or near the dry season.

In an article on the hibernation of the chinch bug, Mr. C. L. Marlatt[a] calls particular attention to the fact that in Kansas the chinch bug in autumn seeks the dense stools of some of the wild grasses in which to hibernate, and to such an extent did this occur that it was suggested as probably the normal hibernating habit of the species.

Before entering into a discussion of this matter, it will be well to present two communications received from the late Dr. J. C. Neal, at that time of Stillwater, Okla. As Doctor Neal was located in a section of the country where, in many cases, civilization had not influenced to such a marked degree the natural insect fauna, the author applied to him to secure some exact information in regard to the chinch bug under such conditions. The correspondence, however, was terminated suddenly by Doctor Neal's death. The two letters here given are among the last he ever penned. They are of a somewhat general nature, and will be referred to later in this discussion.

OKLAHOMA AGRICULTURAL AND MECHANICAL COLLEGE,
Stillwater, Okla., October 31, 1895.

MY DEAR SIR: Yours of the 28th just received. Last year was the first wheat year in most of the new additions to this Territory, and from all sections the cry was for infection, as "the bugs are ruining us." I received letters from every county in the strip and in the western sections. The most damage was done in the extreme southern range of counties, and near Okarche (see map, fig. 10) the damage was excessive. I do not think there is a single acre in this or Indian Territory that is not saturated, so to speak, with the chinch bug. You may put this whole area down as within the infested boundary line. My belief is that the increase of country roads, the decrease of March fires, the shiftless habits of the vast majority of our farmers in allowing volunteer wheat and oats to grow and wheat lands to remain fallow, and the planting of new and better grass crops than the tough blue-stem, are direct causes of what I believe a decided increase of this insect in Oklahoma during the last five years. It would be amusing, if it were not so pathetic, to read the many letters I get, something in this wise: "I planted wheat on sod land; the chinch bugs destroyed it so badly that in February I plowed it up and sowed oats; this, too, went the same way; I then planted corn, and when it was a foot high the little bugs came by the millions and destroyed that; I then planted the land to Kafir corn, and that will be ruined if you can not help me." What could I do for such a man? Had the bugs laid out a programme for their daily sustenance, no better commissary-general could have been obtained for them than he was, and I had to write him that his plan was the worst one possible for him, and the best for the bugs, and that the only suggestion I could make, from the bugs' standpoint and for their benefit, would be to plant wheat again so that they could have something for the coming winter's food. In his case it was a series of fatal mistakes from ignorance of the habits of the bugs.

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[a] Insect Life, Vol. VII, pp. 232–234, 1894.

Another thing which I believe adds materially to the increase of these pests is the complete destruction of the prairie chickens, the decimation of partridges, and the thinning out of all kinds of smaller birds, such as the cow blackbirds, bank sparrows, martins, larks, and other prairie birds. This section is full of reckless boys and men who kill everything that flies, good, bad, and indifferent, "for fun."

Some years ago I went out on the Cherokee Strip, miles away from human habitation, and saw some of the small birds—larks and killdees—busily picking in the young grass, in early spring, and upon examination found these places swarming with chinch bugs sucking the juices of the blue-stem grass.

Almost any time in the winter when the weather is warm one can find chinch bugs, and I have witnessed two "flights" of these insects and determined them. I should be glad to answer any more specific questions at any time.

With regards, I remain,

J. C. NEAL.

The second letter is a short note in reply to the author's question regarding the grasses fed upon by the chinch bug, their hibernating habits, and developments:

STILLWATER, OKLA., *November 20, 1895.*

DEAR PROFESSOR WEBSTER: In reply to your postal, I would say that I do not know, but will at once make observations and report at my earliest chance.

My belief is that the bugs attack all the grass family except the Cenchrus, and that only is exempt on account of its bitter taste, which effectually shields it from insects, as far as I have seen, both in this section and in Florida.

I will take the matter in hand at as early a date as possible and write you progress and results.

Very respectfully, J. C. NEAL.

It is reasonable to infer from these letters that the chinch bug wintered over about the stools of grass, and that the birds were observed to attack them there in early spring, as the statement is made that later, when the young corn was a foot high, the little bugs came by the million. This condition of affairs may be considered in connection with the statements of Dr. Asa Fitch,[a] regarding his observations in Illinois in the autumn of 1854, when in passing over the northern part of the State he found the ground in some places, in the midst of extensive prairies, covered and swarming with chinch bugs, reminding him, as he says, "of the appearance presented on parting the hair on a calf that has been poorly wintered, where the skin is found literally alive with vermin." Further along in his report (p. 290) he states that "so late as the forepart of October I met several of these insects in the pupa state, and some of these I do not doubt would pass the winter in that state, and therefore would not deposit their eggs until the following spring." That he did not find these pupæ in New York is shown by his statement on page 287 of the same report, to the effect that he had "met with but three specimens in New York, occurring on willows in the spring of 1847 and May 12, 1851." As shown farther on in this bulletin, there is no proof that these pupæ did not develop to adults before winter, or die before spring, and the conditions indicated would almost presuppose that hibernation would take place on the prairies where the insects were observed by Doctors Fitch and Neal. From personal recollection the writer knows that the section of Illinois to which Doctor Fitch refers was, at the time mentioned, but thinly populated, and there were still very extensive tracts of the original prairie grasses miles distant from woodlands.

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[a] Second Report on Noxious, Beneficial, and Other Insects of New York, p. 283.

In an interesting note by Mr. E. A. Schwarz[a] on the hibernation of the chinch bug, given in discussing Mr. Marlatt's paper, previously mentioned, attention is called to the fact that the hibernation of the chinch bug had been observed by him, in its maritime home, in the vicinity of Fortress Monroe, Va., which locality he had been in the habit of visiting for a number of years, during the first warm days of spring. The maritime flora and fauna are here late to awake, and most insects peculiar to the seacoast can still be found in their winter quarters by the end of April. By pulling up any good-sized stool of grass and beating it out on the smooth surface of the sand or over a cloth a multitude of various insects are sure to be found, and among them always plenty of chinch bugs. These stools of grass not only serve as winter quarters, but in summer the chinch bugs crawl into them during the daytime to protect themselves from the fierce rays of the sun.

In the timothy meadows of northeastern Ohio the writer has witnessed cases where the chinch bugs had commenced their operations along one side, worked part way across the field, killing the timothy as they advanced, and continued their depredations the following year precisely where they suspended work the autumn before, the long-winged individuals only migrating in the intervening time.

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[a] Insect Life, Vol. VII, pp. 420–422, 1895.

In southwestern Maine, where this short-winged form has occurred in more or less destructive numbers for upward of forty years, and where it affects timothy in the same manner as in Ohio, both long and short winged individuals, the latter in the majority, hibernate under dead leaves, brush heaps, and similar débris in and about the fields where they have ravaged the timothy. They do not appear to select only the drier portions of such fields, but are found also literally swarming about the clumps of rushes (Juncus) that grow in the low spots. Some of these low places become submerged in winter by rains and melting snows, and the hibernating bugs are washed out and killed.[a] Possibly others not observed might have remained among the living timothy, as it is further stated that many hibernating individuals were to be found among the leaves of clover bordering on spots of timothy that had been killed out by them during the preceding summer.

That the short-winged or maritime form must hibernate in or in very close proximity to the field it infests goes without saying, and it would appear that but for the cultivation of timothy it would have become diffused inland from the coast less rapidly, if at all. It is doubtful if this inland diffusion began until the country became settled by the white man and timothy began to be grown by him as a forage crop—a situation that would be coexistent with a diminution in the number and extent of prairie and forest fires.

West of the Allegheny Mountains we encounter this short-winged maritime form only in western Pennsylvania, northern Ohio, southern Michigan, extreme northern Indiana, and equally extreme northern Illinois. The writer once found a single short-winged individual in southern Ohio, and a single individual that may or may not belong to this species has been recorded from New Mexico by Prof. T. D. A. Cockerell.

Except as indicated in the preceding paragraph, over this whole country the long-winged form is the only one known, and its habits are almost as unlike those of the maritime form as they would be were the latter a different insect. Timothy culture has never extended to the Gulf coast, and the extensive growing of the crop over this whole western country is of recent date, coexistent with the advent of the white man. Here, therefore, timothy is not attacked by chinch bugs.

The inland or long-winged form inhabits largely a prairie country, and it would appear that, as these prairies were annually burned over during the hibernating season, the form that became the most scattered prior to hibernation would be likely to stand the best chance of surviving. It seems to the writer that the wings of the chinch bug might have been, in early days in the Mississippi Valley, kept up to a high standard of development by the necessity of such an escape from prairie fires and not by the presence of *Sporotrichum globuliferum*, as suggested by Professor Sajö in his paper, a translation of which is included herein under the heading, "Habits of the European species, *Blissus doriæ* Ferr."

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[a] Nineteenth Ann. Rept. Maine Agric. Exp. Sta., 1903, pp. 41–52.

As mentioned farther on, the advance of civilization having revolutionized the face of the country, there has come a corresponding change in the hibernating habits of the chinch bug. This insect must now seek shelter in the limited patches of timber that are left in the sections that were once entirely wooded and in the matted grass along fences and roadsides, but especially among the fallen leaves and rubbish that usually accumulate along Osage orange hedges. Brush piles, old haycocks, strawstacks, and, in Ohio, at any rate, shocks of corn fodder left standing in the fields through the winter, all harbor chinch bugs during the hibernating season.

The fact that the insect hibernates in matted bluegrass along roadsides and fences has been called in question by Professor Forbes and by Mr. Marlatt, the former in his first report as State entomologist of Illinois (p. 37) and the latter in Insect Life (Vol. VII, p. 232), but notwithstanding this, in some parts of Ohio, in Indiana, and Illinois they do hibernate in just such places and can be found there, especially during the winter and early spring following a season of abundance, but the investigator must know how to search for them. The writer has found them late in the fall collected under rails, half buried in soil and dead grass, and in northern Illinois, while searching for other insects in early spring, he was sure to find them in varying numbers with small Carabidæ, Staphylinidæ, and other early appearing insects, on the under side of boards laid down in grassy places, though no amount of searching the grass itself would have revealed their presence.

In the timothy meadows of northeastern Ohio the percentage of long-winged individuals is always much greater in fall than in June, showing that some, at least, hibernate there and migrate to the cultivated fields in spring. In Maine, in the case of the maritime form, of 565 bugs collected in hibernation in October, 1902, only 60 had long wings.[a] In Kansas, where Mr. Marlatt made his observations, there was still too much prairie, and the species was doubtless still adhering to its ancient habits of hibernation. In southern Ohio the author has found it attacking the wheat in May, in small isolated spots over the fields, while there was nothing in the least to imply an invasion from outside, but the wheat had been sown in the fall among corn, and later the cornstalks cut off and shocked, remaining in this condition until the following spring. This occurred so frequently that there seemed no room to doubt that the attacks had been caused by adults wintering over in the corn fodder, and that these left their winter quarters in spring to feed and breed on the grain growing nearest at hand.

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[a] 19th Rept. Maine Agric. Exp. Sta., 1903, p. 48.

Prof. Herbert Osborn,[a] in giving a summary of his observations on the chinch bug in Iowa in 1894, states that "In a great majority of cases, 90 per cent or more, the infested fields were directly adjacent to hedges or thickets or belts of timber, and in 75 per cent Osage orange hedges were the most available shelter. In about 13 per cent of the cases the evidence showed hibernation in grass and weeds, and in some of these cases there could scarcely be a doubt that the hibernating bugs were protected by a heavy growth of grass or weeds and that they moved from these directly into the adjacent grain fields." Prof. Lawrence Bruner had previously called attention to the fact that the chinch bug hibernated in great numbers about Osage orange hedges in Nebraska. Doctor Lugger, in Minnesota, gives the following as offering shelter to the bugs during winter: "Rubbish of all kinds, but chiefly that of hedges, wind-breaks, and along the edges of woods, as well as corn fodder, logs, and even loose bark and stones."

While drenching rains are beyond all possible doubt fatal to the newly hatched young, the adult bugs seem to be almost proof against either wet or cold weather. It is doubtless true that very many individuals die in their winter quarters, and in fact the writer has found these dead in considerable numbers in some instances during early spring, but it seems at least doubtful if either cold or wet would entirely account for this fatality. It would seem that somewhere and at some period in the past this hibernation has been more for protection from natural enemies than against the elements, though of course there might have been other reasons not discernible under a changed environment. The pupa hides away to molt, though it does not appear that this course is followed in the earlier stages, and the reasons for this are not at all clear. That the adult is able to withstand combined cold and wet weather is amply proved by the observations of several people. Dr. Hy. Shimer, in Illinois, found that those which were in corn husks filled with ice, even the chinch bugs themselves being inclosed in the crystallized element, were able to run about when they were thawed out, apparently unaffected by a temperature that had varied from 15° to 20° below zero Fahr. It seemed that when exposed to the sweeping prairie winds at that temperature, with no protecting cover, they perished. Mr. G. A. Waters, in the Farmers' Review for October 19, 1887, relates that a bunch of fodder that had fallen into a ditch washed out near a corn shock by heavy rains became covered with water that stood over it long enough for a sheet of ice to form. When the water had subsided the corn was husked and a number of chinch bugs were found among the ears, where they had been immersed for a week or more; yet on being exposed to the warm sun they began to crawl about in a lively manner.

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[a] Chinch Bug Observations in Iowa in 1894, Insect Life, Vol. VII, pp. 230–232.

The Maine Agricultural Experiment Station some years ago[a] carried out a series of experiments with the maritime form to determine the effect of freezing. Ten long-winged and 6 short-winged bugs were frozen in an open box for fifteen hours. Upon thawing out 2 gave no signs of life. After being kept for nine hours at a temperature of 65° the 14 surviving bugs were refrozen for fifteen hours and then thawed out, when 5 long-winged and 3 short-winged revived. After nine hours at a temperature of 65° they were frozen a third time for fifteen hours, during which time the minimum temperature sank to 16° below zero. When thawed out all revived, but during the following nine hours at 65° temperature the 3 short-winged bugs and 2 of the long-winged ones died. The remaining 3 long-winged were then frozen a fourth time for fifteen hours, after which none revived.

In summarizing the results of these experiments, 25 in number. it was found that complete submersion in water, even for a considerable period, is not necessarily fatal. Freezing during submersion in water is almost surely fatal. Freezing while exposed to dry atmosphere is generally fatal. Freezing in a moisture-laden atmosphere is only occasionally fatal. It will be observed, however, that not all of these results would necessarily follow corresponding experiments with the inland long-winged form.

SPRING, SUMMER, AND AUTUMN MIGRATIONS.

If there is an ample supply of proper food close at hand the chinch bug simply crawls from its hibernating place, but if it is in the timothy meadows of northeastern Ohio it does nothing but continue its ravages where it left off the autumn before, except some of the long-winged form, which very evidently fly to the wheat and corn fields. In wheat fields—unless the migration has been from an adjoining field, in which case the attack is made along the edge nearest thereto—the females do not seem to forsake their gregarious habits entirely, as they do not scatter out evenly over the entire field, but appear to locate in colonies, and when the young hatch and begin to attack the growing grain their presence is first disclosed by small whitening patches, which increase in dimensions as the young become older and more numerous. In low-lying fields these whitening patches more commonly appear on the back furrows or on any slight elevations that occur in the field. But on higher and level ground the whitening areas are observed scattered over the entire field, and constantly widening until the whole field appears to ripen prematurely and crinkle down. When the migration is accomplished by crawling, the females seem to spread only enough to afford food for the young until the latter are able to make their own way from place to place. The young remain clustered on the plant about which they were hatched until this has been drained of sap, when they make their way, almost in a body, to a second plant, and in this way an attack will be pushed forward day after day.

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[a] Nineteenth Rept. Maine Agric. Exp. Sta., 1903, p. 48.

In the spring the chinch bug probably lingers about its winter quarters until a favorable day for migration occurs. Transfer a typical Indian summer day to early May, and perhaps raise the temperature a few degrees, and you have a day during which chinch bugs may be seen on the wing, crawling along on fences, or at rest on the tops of fence posts as if taking observations, and in reality, as the writer has come to believe, to catch the scent of wheat or corn fields. It is on just such a day as this that *Aphodius serval* Say will be observed posted in precisely the same way, opening and closing the leaves of its antennæ, evidently to catch the scent of the fresh droppings of animals. The same movements characterize *Aphodius inquinatus* Hbst. during the Indian summer days of autumn. The writer has also observed the plum curculio, *Conotrachelus nenuphar* Hbst., acting in precisely the same way in late autumn.

While discussing the subject of chinch-bug migrations, it may be best to state here that there is a second flight of chinch bugs in summer after the majority have become fully developed, and not as soon as the individual reaches the adult stage, as Professor Sajö has found to be the case with the European species, *Blissus doriæ* Ferr. A migration by flight takes place in the fall, usually during the period of Indian summer. The magnitude of such migrations depends in the spring on the number of individuals that have been in hibernation, and in the summer and fall entirely on the abundance of the species during the current year. If there has been no great abundance during the spring the summer flight will not be likely to attract attention. During the invasion of 1896 in Ohio an individual alighted on the writer's hand while he was riding on a street car in the heart of the city of Columbus. A heavy storm of rain has much influence in scattering the bugs in midsummer, and just preceding a heavy rain the writer has noted the fully developed adults very abundant on Indian corn plants, while immediately after the storm there would be very few to be found. As these storms were not always accompanied by high winds, it is probable that it is the rainfall that scatters the insects.

In timothy meadows where the original attack has begun along one side and gradually extended inward, the line of separation between the entirely dead grass and that uninjured is frequently not over a yard in width, and within this narrow, irregular strip we may have the dead and brown, the yellowing indicating more or less serious injury, and the perfectly healthy green of unattacked plants. This many-colored border may change but little in the space of a week or ten days, except to advance very materially, leaving the grass completely dead or dried up, while the clover plants are uninjured. This indicates that the females, after leaving their places of hibernation, do not spread out over any large area, but to a certain degree maintain their gregarious habits. The author believes that these habits have been shaped by some past environment in which the species has been placed for a long period of time, as, for illustration, the inhabiting of bunches or tufts of grass more or less isolated from each other.

To what extent pairing takes place in these places of hibernation before the insects make their way to the cultivated crops is a matter of considerable uncertainty. From his own observations the writer is inclined to believe that only a very insignificant minority follow this course.

In his "Wanderings of Insects" Prof. Karl Sajö has called attention to the influence of electrical storms in the dispersal of insects, and it is quite possible that adult chinch bugs may be thus affected by the heavy thunder that usually accompanies these storms, during which they seem to disappear from corn plants on which they had previously congregated.

OVIPOSITION.

According to most writers the eggs are deposited either about or below the surface of the ground, among the roots of the grass or grain. It is more than likely that the place varies with the conditions, as the eggs are not infrequently found above ground about the bases of the plants, and even upon the leaves, though we have never found them there, but have often found them under the sheath of grasses. It would seem, then, that the eggs require a cool, damp, but not a wet location.

EGG PERIOD AND NUMBER OF EGGS DEPOSITED BY EACH FEMALE.

Doctor Shimer states that each female deposits 500 eggs, scattering them over a period of from ten days to three weeks, and as the adult develops in fifty-seven to sixty days after the eggs are deposited, or about forty-two days after hatching, it will be seen that some of the earliest hatched young are well along toward full development by the time the last eggs are being deposited. According to Doctor Riley, the eggs hatch, on the average, in two weeks.

In a series of breeding-cage experiments Prof. W. G. Johnson found that each female deposited from 98 to 237 eggs, the egg period lasting from eighteen to twenty-one days, and the period of oviposition covering from thirty-eight to forty-two days. Forbes also records in his Fifth Report (p. 44) experiments showing that the period of incubation may cover from twelve to twenty-two days. (See Forbes's 19th Report, pp. 177–183.) It must be remembered, however, that Professor Johnson had but six females employed in his experiments and that these were necessarily under an artificial environment.

DESCRIPTIONS OF THE DIFFERENT STAGES OF DEVELOPMENT.

The following descriptions of the egg and various stages of the young bugs are taken from Riley's Seventh Missouri Report, while that of the adult is from the original by Thomas Say, as published in his American Entomology (Vol. I, p. 329, Le Conte Ed.):

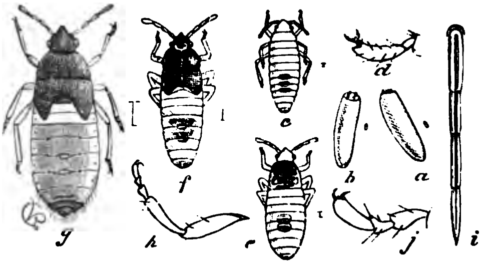

FIG. 2.—*Blissus leucopterus: a, b,* eggs; *c,* newly hatched larva; *d,* its tarsus; *e,* larva after first molt; *f,* same after second molt; *g,* pupa; the natural sizes indicated at sides; *h,* enlarged leg of perfect bug; *j,* tarsus of same, still more enlarged; *i,* proboscis or beak, enlarged. (From Riley.)

The egg.—Average length 0.03 inch, elongate-oval, the diameter scarcely ¼ the length. The top squarely docked and surmounted with four small rounded tubercles near the center. Color, when newly laid, pale or whitish, and translucent, acquiring with age an amber color, and finally showing the red parts of the embryo, and especially the eyes toward tubercled end. The size increases somewhat after deposition, and will sometimes reach near 0.04 inch in length. (Fig. 2, *a, b.*)

Larval stages.—The newly hatched larva is pale yellow, with simply an orange stain on the middle of the three larger abdominal joints. The form scarcely differs from that of the mature bug, being but slightly more elongate; but the tarsi have but two joints and the head is relatively broader and more rounded, while the joints of body are subequal, the prothoracic joint being but slightly longer than any of the rest. The red color soon pervades the whole body, except the first two abdominal joints, which remain yellowish, and the members, which remain pale.

After the first molt the red is quite bright vermilion, contrasting strongly with the pale band across the middle of the body, the prothoracic joint is relatively longer, and the metathoracic shorter. The head and prothorax are dusky and coriaceous, and two broad marks on mesothorax, two smaller ones on metathorax, two on the fourth and fifth abdominal sutures, and one at tip of abdomen are generally visible, but sometimes obsolete; the third and fourth joints of antennæ are dusky, but the legs still pale. After the second molt the head and thorax are quite dusky and the abdomen duller red, but the pale transverse band is still distinct; the wing pads become apparent, the members are more dusky, there is a dark-red shade on the fourth and fifth abdominal joints,

> and, ventrally, a distinct circular dusky spot, covering the last three joints. (Fig. 2, *c*, *d*, *e*, *f*.)
>
> *The pupa.*—In the pupa all the coriaceous parts are brown-black, the wing-pads extend almost across the two pale abdominal joints which are now more dingy, while the general color of the abdomen is dingy gray; the body above is slightly pubescent, the members are colored as in the mature bug. the three-jointed tarsus is foreshadowed, and the dark horny spots at tip of abdomen, both above and below, are larger. (Fig. 2, *g*.)
>
> *The adult.*—Blackish, hemelytra white with a black spot.
>
> Inhabits Virginia.
>
> Body long, blackish, with numerous hairs. Antennæ, rather short hairs: second joint yellowish, longer than the third; ultimate joint rather longer than the second, thickest; thorax tinged with cinereous before, with the basal edge piceous; hemelytra white, with a blackish oval spot on the lateral middle: rostrum and feet honey-yellow; thighs a little dilated.
>
> Length less than three-twentieths of an inch.
>
> I took a single specimen on the Eastern Shore of Virginia.
>
> The whiteness of the hemelytra, in which is a blackish spot strongly contrasted, distinguishes this species readily.

To the foregoing description of the adult Dr. Asa Fitch, in his second report on the Insects of New York, adds brief descriptions of nine varieties, all, with but one exception, being based upon slight variations in color. some, perhaps, being due to immaturity, the single exception being the short-winged inland form, of which variations from the nearly wingless to fully winged are shown in figures 3 and 4.

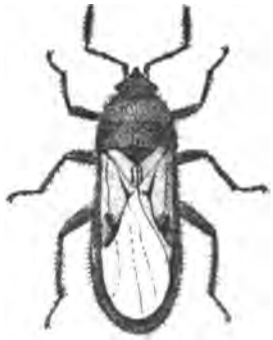
FIG. 3.—*Blissus leucopterus*: adult of long-winged form. Much enlarged (original).

Leaving, then, out of consideration the color varieties as arranged by Doctor Fitch, we have a long-winged form (fig. 3) in which individuals from the eastern portion of the country differ from those found in the West by being more hairy and robust, as pointed out by Mr. Van Duzee, and a short-winged form (fig. 4), found along the seacoast, and in the North Atlantic Coast region, extending inland as far as the country adjacent to the Great Lakes.

DEVELOPMENT AND HABITS OF THE YOUNG.

The newly hatched young are very active, and the first to appear may be observed with their progenitors about the bases of wheat, corn, or grass plants, and later all stages are seen mingling together, having little appearance of belonging to the same species, so greatly do they vary in size and color in their several stages of development.

As a rule the bugs confine themselves to the lower portion of the plants attacked, but may later push their way upward, especially if the lower portion becomes tough and woody, finally covering the plants in patches, as seen in figure 5, where they are shown on a stalk of young corn. Mr. E. A. Schwarz relates a curious exception to this habit in Florida upon sand oats, *Uniola paniculata*, where the entire development of the insect is undergone upon the highest part of this tall plant and not close to the bottom. Mr. Schwarz has given as a probable reason for this the fact that strong winds are continually blowing the fine, sharp sand through among the lower parts of the plants, rendering it nearly or quite impossible for the bugs to remain in that situation, thus forcing them to seek their sustenance farther up the plants. While figure 5 gives a good representation of the appearance of a corn plant when the chinch bugs are present in excessive numbers, yet the writer has invariably found that these bugs much prefer a stalk that has been blown down by the wind or partly broken off by the plow and left lying nearly flat upon the ground.

In timothy meadows the very young are to be found only by pulling away the soil from about the bulbous roots and drawing down the dead sheaths that usually envelop them. An observer may even pull up a tuft of grass entire, and yet, unless he examines in this way closely, may overlook them, so snugly are they thus ensconced among the roots. If driven to forsake a tuft of grass the young bugs move to another and crawl downward, and are soon to be found as snugly settled as before. It is only when they are older and well advanced toward maturity that they work to any extent above ground, and even then only in cases where they are present in great numbers. Singularly enough, where infested meadows are plowed up and planted with corn the females seem to ignore the young corn plants and select the occasional stray clumps of timothy that cultivation has failed to destroy and deposit their eggs about these, so that later the young may be swarming about these last, while hardly one is to be found about the young corn. This is precisely the opposite of what is observed farther west.

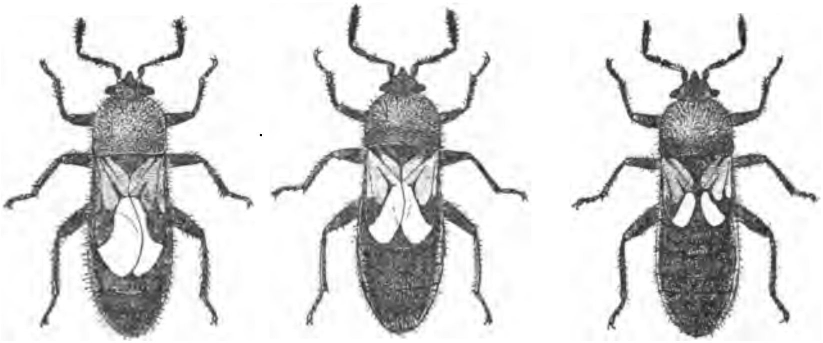

FIG. 4.—*Blissus leucopterus:* adults of short-winged form. Much enlarged (original).

Although living externally on their food plants, and notwithstanding the fact that the young may attack the bases or even the roots of some of these, the species is essentially an external feeder, and appears while thus engaged almost totally indifferent to possible attacks of natural enemies. When not feeding, however, there is at times a tendency to hide away under the sheaths of young corn or beneath clods of earth or bunches of coarse stable manure, where this has been recently applied and left more or less exposed on the surface of the ground. The writer has noted this in cases where neither an uncomfortable temperature nor wet weather necessitated protection.

As has been shown in the description of the larval stages, there are four molts between the egg and the adult state. Just how the molting larvæ act we have never been able to determine; neither have we witnessed pupation, but a fully developed pupa that is ready to molt is easily distinguished by its larger size and more tightly fitting skin, which is almost shining white on the median ventral surface of the abdomen. It now hides itself away, seemingly preferring to get under the sheaths of grasses or grains; but if these are not convenient it will crawl under loose clods, or even into crevices in the ground. While thus hidden away the pupa skin splits along the back and the fully developed adult makes its way out, leaving the empty skin behind. These last are very frequently mistaken for dead chinch bugs, and, when moldy, the farmer is very likely to suppose that they are bugs which have been killed by the fungus *Sporotrichum globuliferum*, if this has been applied in the fields.

On first emerging from the pupa the adult is generally of a dull pink color, except the wings, which are white, exclusive of the veins; these being of the same pinkish hue as the body. In a short time these colors change to the normal ones of the species, but during the breeding season these newly developed adults may be observed crawling about with the young of all stages as well as the maturely colored adults.

If this development has been taking place in a wheat field and the grain is harvested at this time, or if from any other cause the food supply becomes suddenly exhausted, all sizes of larvæ with pupæ and adults will start off on foot to hunt for a fresh supply. Though many individuals may now have become fully developed, and, so far as can be determined, possess wings entirely fitted for active service, nevertheless they will crawl along a dusty road or across freshly plowed fields in company with their less fortunate fellows, seemingly never for a moment supposing that they can span the intervening space by flight. The writer is totally unable to account for this phenomenon in the species at this time, the disinclination to use the wings being so wholly unlike the habits of *B. doriæ*, as shown by the careful and painstaking observations of Professor Sajö in Hungary. Again, the seeming desire on the part of the pupæ to secrete themselves while transforming to adults does not at all coincide with the idea of a supposed immunity from attacks of natural enemies. Surely our species of Blissus has not always lived where natural enemies were as few as they are with us at the present time. Even where we have both the long-winged and short-winged forms occurring together in timothy meadows there is no such haste exhibited on the part of the former to escape from the companionship of the latter, as observed by Professor Sajö. We know, however, that our species certainly does enjoy a considerable immunity from natural enemies, though its conspicuous colors in both the larval and adult stages contrast very strongly with those of its usual food plants and its presence is still further advertised by its strangely persistent gregarious habits. We have come to suppose the species to be, in part at least, protected from attack by its vile odor, and so, indeed, it may be in the United States, but the writer fully believes that somewhere in its southern habitat it will be found to have one or more enemies, like the ant, *Eciton hamatum* Fab., of Central America, for illustration. Our native ants, however, will seldom attack even the young.

NUMBER OF GENERATIONS ANNUALLY.

Over the most of its area of habitation in North America, at least, the chinch bug is two brooded, though in northeastern Ohio the writer has totally failed to detect the second brood, or, in fact, to perceive any indications that a second brood occurs; but this will be referred to later. As previously shown, there is not sufficient proof at hand to warrant the statement that there is, even in the far South, a partial third brood. It is probable that the number of broods of this species annually has been primarily decided in its home in the tropical regions by the wet and dry seasons occurring there, and that we have in the North these same broods occurring at slightly different periods under the influence of a change from wet and dry to hot and cold seasons.

Belt, in his Naturalist in Nicaragua, has the following to say with regard to the seasons on the northeastern side of that country: "The rains set in in May and continue with occasional intermissions until the following January, when the dry season of a little more than three months begins" (p. 103). "The heaviest rains fall in July and August, and at those times the brooks are greatly swollen." "In September, October, and November there are breaks of fine weather, sometimes lasting for a fortnight, but December is generally a very wet month, the rains extending far into January, so that it is not until February that the roads begin to dry up" (p. 104). It seems that possibly we have here the key to the secret of the number of broods annually of the chinch bug. That this insect may be able to adapt itself still further to changed latitude and environments and become single brooded is not at all impossible. As illustrating the ease with which insects, at least some of them, can change their habits to correspond with their environment, we have in South Australia the following facts regarding the codling moth, *Carpocapsa pomonella* L., of which, though being still double brooded, "the winter caterpillars hatch into moths irregularly from the beginning of October until the middle of November and deposit their eggs accordingly, giving rise to a succession of young caterpillars until the beginning of December. About the third week in December the first moths of the second brood begin to appear and deposit eggs, and members of this second generation of moths continue hatching and egg laying until the end of February."[a]

The author's notes on the chinch bug in northeastern Ohio are as follows: Very young larvæ, with what appeared to be their progenitors, were observed at Jefferson, Ashtabula County, within 11 miles of the shores of Lake Erie, June 16, 1893, there being no advanced larvæ among them. On August 27, 1896, a few miles south, at West Andover, in the same county, only adults were observed in two days' search, though some of these showed by their color that they had but recently passed the pupal stage. In this latter locality, May 7, 1897, the sexes were pairing, but no young were present so far as could be observed, while to the south and west of this locality, June 8 and 9, precisely the same conditions obtained as to the bugs, no young appearing at this time. Quite copious rains might have destroyed the young, but within 15 miles of these localities, on July 14 of this year, larvæ were found after first molt and stages intervening between these and the adults. Near Youngstown, on October 3, 1897, only adults were present, pairing was not in progress, and the insect was not pairing in Ashtabula County on August 27, 1896. June 9, 1898, only two very young larvæ could be found at Salem, about 15 miles southwest of Youngstown.

Up to October 17, 1898, no young of a second brood had been observed, though careful search had been made from time to time in the fields and meadows of northeastern Ohio, and a large number of adults which developed in July and August, and since kept in confinement, had not only not reproduced, but had shown no disposition whatever to pair. On the other hand, in southwestern Ohio, in the vicinity of Cincinnati, on September 24, where the species occurred in abundance, fully 75 per cent were pupæ, the remainder being made up of larvæ, some of them quite young, and adults in about equal proportions, some of the latter showing by their immature colors that they had but just passed the pupal stage.

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[a] George Quinn, in Journal of Agriculture and Industry, South Australia, Vol. I, p. 112.

Hatching is not fully in progress in the Northeast before the 25th of June, only an occasional individual having passed the first molt before the 10th of July. In the light of the information that has been gained by these observations, the occurrence of a second brood of young in northeastern Ohio is doubtful.

The late Dr. J. A. Lintner, in his studies of the outbreak of this insect in New York State in 1882 and 1883, seems to have relied much on the published habits of the species farther west—as, indeed, the writer has himself done until recently—and made no exact studies of the species at that time; and in his annual report, where the outbreak is discussed, no absolute proof of the existence of a second brood in New York is presented.[a] The occurrence of a second brood of young in northern Illinois, as indicated by Doctor Fitch, has always been considered as settled, and in a more northern latitude than northern Ohio, so that there must be some other influences besides latitude to account for the phenomenon. That the species has occupied this territory for many years is indicated by the observations of Mr. E. P. Van Duzee, of Buffalo, N. Y., who wrote that the insect was as abundant twenty-three years ago as at the present time, so that whatever effect on the insect the recent occupation of the country might have had, that effect has passed away and a condition of what we might call equilibrium now exists here.

On July 7, 1889, in the extreme northern part of Indiana, the writer found an abundance of young which had not yet molted for the first time. Dr. A. S. Packard records adults as pairing at Salem, Mass., June 17, 1871, as quoted by Doctor Lintner, while the latter gentleman[b] records the young as occurring in Lawrence County, N. Y., about June 5, 1883.

Hardly have the latest hatched young of the first brood developed to the adult before the young of the second brood begin to appear. In southern Ohio this is about the first week in August. Generally these young do little injury, because the wheat has long since been harvested and the corn is usually too far advanced and tough to offer a desirable source of food supply, except in cases where fields have been planted very late, and here the writer has known them to work considerable injury, especially in seasons of severe drought that prevented the rapid growth of the plants. Fall attacks on wheat are rare, and the injury is never of a serious nature, as it is usually the case that by the time the young wheat is large enough to invite attack the chinch bugs are searching for winter quarters.

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[a] Second Report State Entomologist of New York, pp. 148–164. 1885.

[b] Loc. cit., pp. 158, 159, 164.

In the timothy meadows of northern and northeastern Ohio, however, the principal injury is done during August and September, and in favorable weather on into October. Now, if we allow sixty days for development from the egg, it would be September before the appearance of the adults of the brood to which these various young belonged. If all eggs were deposited immediately, it would be November before the adults of the second brood would begin to occur, a condition of affairs that has never been observed. As previously shown in this bulletin, the first brood is fully developed in northeastern Ohio by the first of September, but there certainly is no indication that a second brood of young is developed during September and October. It would seem, then, that from northern Ohio through New York, New England, and probably to Nova Scotia the adults from the first brood of larvæ winter over, and that there is here but one annual brood.

DESTRUCTIVENESS LARGELY DUE TO GREGARIOUS HABITS.

Attention has been directed previously to the gregarious habits of the chinch bug, and we only refer to the phenomenon again because it is to this that its destructiveness is largely due. It is not the excessive numbers, but the persistency with which they will congregate *en masse* on limited areas, that renders their attacks so fruitful of injury. With an ample supply of food the young develop and leisurely diffuse themselves over the adjacent fields, and there are neither swarming flights nor migrations. In 1884, in northern Indiana, a small field of wheat was severely attacked by chinch bugs. At harvest there was every prospect of a migration from the field of wheat to an adjacent one of corn, and the bugs were present in sufficient numbers to have worked serious injury to the latter; but the wheat had grown up thinly on the ground, and there had sprung up among the grain a great deal of meadow foxtail grass, *Ixophorus* (*Setaria*) *glaucus*, and panic grass, *Panicum crus-galli*, and to these grasses the bugs transferred their attention, finishing their development thereon, and later, so far as could be determined, they scattered by flight out over the adjacent fields, working no further injury. Pedestrian migrations may continue for a fourth of a mile or even more, but on reaching a suitable food supply the tendency of the bugs is to congregate upon their food plants until these are literally covered with individuals varying in color from the black and white of the adults to the bright vermilion of the more advanced larvæ. (See fig. 5.) Whatever tendency there is exhibited toward a wider diffusion is confined to the adults, the others remaining and leaving in a body only when the plant on which they have congregated has been drained of its juices and has begun to wither, when they simply crawl to the nearest plants and again congregate upon these as before. In case the migration has been to a field of corn, if this is badly overgrown with either of the two grasses previously named, the bugs will collect upon the latter, and unless the corn plants are very small they will not as a rule attack them until the grass has been killed. Some farmers have gone so far as to claim that a benefit is derived from a certain abundance of chinch bugs, the statement being made that the bugs will kill out these grasses to an extent that nothing else will. It is clear that the acquisition of wings is not the signal for the adults to abandon the companionship of the larvæ and pupæ, yet they do gradually disappear from among them. It is possible that the disposition to pair does not exist until the individual has reached a certain age beyond seeming maturity, and that it is not until the passion for mating has overcome their gregarious inclination that they are disposed to migrate. Or it may be that the phenomenon may be explained on the supposition that when the pairing season approaches the males scatter out in order to find females with which they are not akin, thus following out natural selection and preventing a continual interbreeding. Over the northern United States, at least, the injury in cultivated fields is done almost entirely by the young bugs, but in the timothy meadows the damage is due as much, if not more, to the depredations of the adults.

FOOD PLANTS.

As to food plants, there can be no doubt that these consisted originally of the native grasses. This is amply proved by the observations of Fitch and Le Baron, in Illinois; Dr. J. C. Neal, in Florida and Oklahoma; Marlatt, in Kansas; Schwarz, in Florida; and by those of Mr. Henry G. Hubbard in the midst of the Colorado desert in California. Regarding this last statement, Mr. E. A. Schwarz wrote as follows:

> You may be interested to learn that chinch bugs were collected this year (1897) on March 28 by Mr. H. G. Hubbard, at Salton, in the midst of the Colorado desert of California. This locality is considerably below the ocean level, and represents an ancient extension of the Gulf of California. Even at the present time the Salton Basin is occasionally flooded, the water entering through New River, which runs from the mouth of the Colorado River into the Salton Basin. The specimens were taken on a species of coarse grass which is incrusted with a saline deposit.

No wonder that the chinch bug is accused of being a seashore species!

Of cultivated grasses, or such as occur in cultivated fields, probably *Ixophorus glaucus* and *Panicum crus-galli* are the favorites, though millet and Hungarian grass are apparently nearly as attractive. As early as 1845, in Illinois, Dr. William Le Baron, afterwards State entomologist, gave the food plants of the chinch bug as follows:

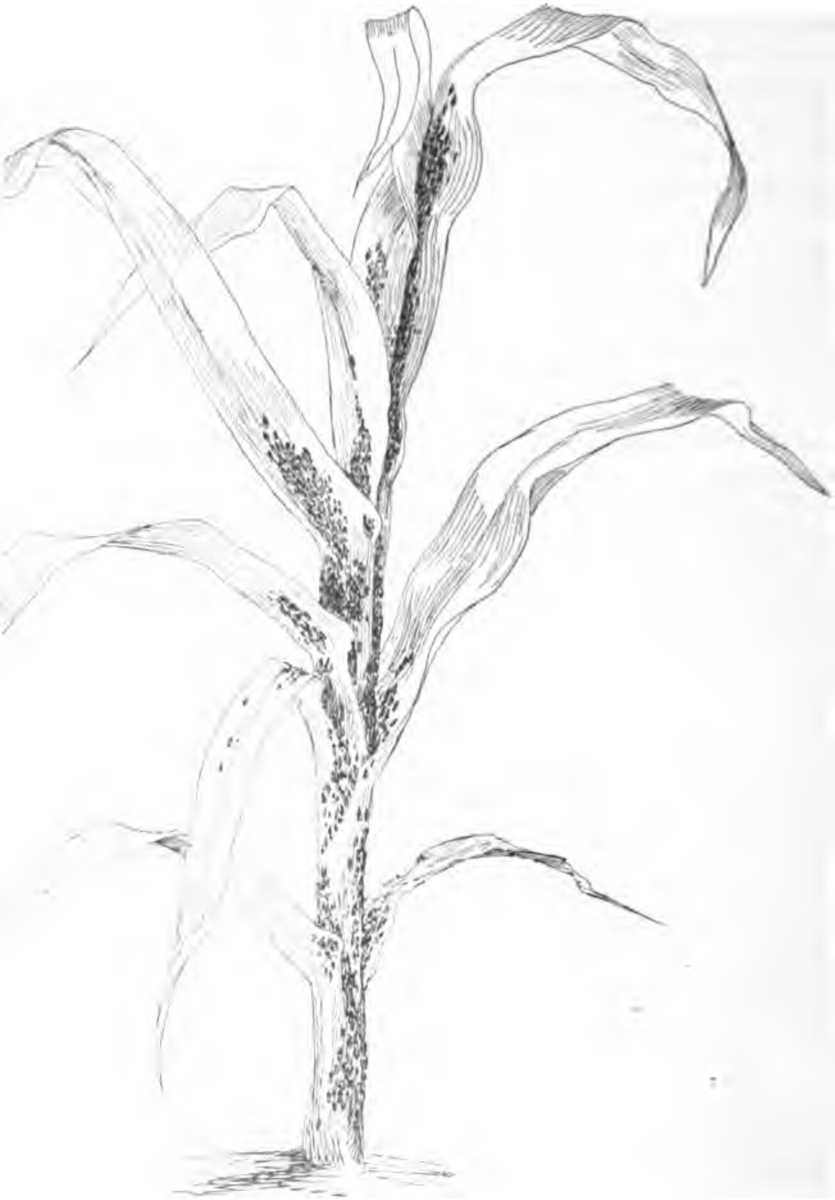

FIG. 5.—Corn plant two feet tall infested with chinch bugs. (Author's illustration.)

* * * "all kinds of grain, corn, and herd's-grass" (timothy).[a] But to this day in Illinois, as shown by the observations of Professor

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[a] Prairie Farmer, December, 1845.

Forbes and the writer, the species will attack timothy only in cases where it is compelled to do so by reason of a lack of other food. In addition to the preceding, Doctor Howard gives broom corn, sorghum, chicken corn, Bermuda grass (*Capriola dactylon*), bluegrass (*Poa pratensis*), crab grass (*Syntherisma sanguinalis*), and bottle grass (*Ixophorus viridis*), and also states that in the rice fields near Savannah, Ga., in August, 1881, he observed the winged adults upon the heads. Prof. H. A. Morgan wrote that in 1897 it had become a serious enemy to "Providence" rice in Louisiana, where for two years it had seriously injured corn, and the writer was informed through other sources that it proved injurious to corn again in 1898. Adults have often been found collected in the silk of belated ears of corn in the fields in September, when all other parts of the plant had either become too old and tough to afford nourishment or else had been killed by the frosts of autumn. Prof. Lawrence Bruner has recorded the insect as feeding upon so-called wild buckwheat (*Polygonum dumetorum* or *P. convolvulus*).[a] The writer has never seen chinch bugs attack bluegrass (*Poa pratensis*), and has seldom witnessed them injuring oats, but on September 27, 1904, he observed larvæ, pupæ, and adults, the last all fully winged, attacking Arrhenatherum (oat grass) on the experiment farm of the University of Tennessee, at Knoxville. Over the western country the major portion of the damage done is to fields of wheat, barley, rye, and corn, the outbreak generally originating in wheat or barley fields and the bugs migrating at harvest to the cornfields. (See fig. 5.) In the eastern part of the country, where the timothy meadows are the most seriously infested, this is not the case, and here the migrations are as likely to be to the timothy meadows as to the fields of corn, where both are equally within reach. Besides, everything indicates that a very large proportion of the adults may hibernate in these meadows, even making their way thereto in the autumn.

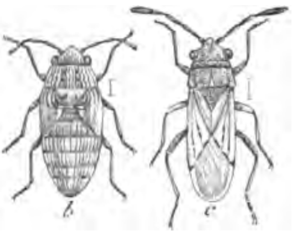

FIG. 6.—*Nysius angustatus*: *b*, pupa; *c*, mature bug. (From Riley.)

INSECTS THAT ARE MISTAKEN FOR CHINCH BUGS.

Messrs. Osborn and Mally[b] have given a list of twelve species of Hemiptera which have been mistaken with more or less frequency for the chinch bug, the list being as follows:

Nysius angustatus Uhl., the false chinch bug (fig. 6), is probably the most frequently mistaken for the true chinch bug, as it often breeds in considerable numbers under purslane, amaranth, etc., and more than any other insect resembles the chinch bug. It is, however, of a light-gray color, which will always distinguish it from its more destructive fellow.

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[a] Report Commissioner of Agriculture, 1887, pp. 57–58.

[b] Bul. No. 32, Iowa Agr. College Exp. Sta., pp. 363 385.

Ischnodemus falicus Say, or the long chinch bug, as it is sometimes called, is much larger and longer than the true chinch bug.

Ischnorhynchus didymus Zett. is more robust, of a light-tawny color, with prominent, glassy wings.

Peliopelta abbreviata Uhl. is, next to the false chinch bug, probably the most often mistaken for the true insect, and especially is this true in localities where the brachypterous form of *Blissus leucopterus* abounds, viz, in timothy meadows. Its broader head and body, however, quickly enables one to distinguish it.

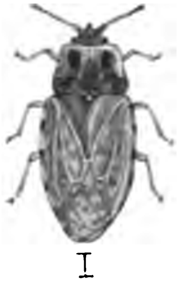

FIG. 7.—*Piesma cinerea.* (From Riley.)

Geocoris fuliginosus Say, *G. borealis* Dallas, *G. bullatus* Say, and *G. limbatus* Stål, according to Osborn and Mally, have all been confused with the chinch bug in Iowa. These are all broader and flatter than the true chinch bug, the head being nearly as wide as the thorax.

Ligyrocoris sylvestris L. is larger than the true chinch bug, and its wings are quite dark instead of white.

Trapezonotus nebulosus Fall. is a trifle larger and its body is not so black as in the chinch bug.

Cymodema tabida Spin. is longer than the true chinch bug, of a light brown color, and the ends of the wings are glassy.

Triphleps insidiosus Say, or the insidious flower bug (fig. 15), as it is more commonly called, is another bogus chinch bug, though an enemy of the true pest, as previously stated.

Piesma cinerea Say, the ash-gray leaf bug (fig. 7), is often mistaken for the true chinch bug, though its form differs greatly from that of the latter. It is often quite abundant, but not in grain fields or meadows.

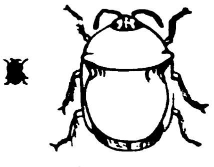

FIG. 8.—*Corimelæna pulicaria.* (From Riley.)

Corimelæna pulicaria Germ., the flealike negro bug (fig. 8), has been confused with the chinch bug; though it does not in the least resemble the latter, either in form or color, and its confusion is probably to be accounted for by the fact of its being occasionally found in wheat fields in considerable numbers.

Brachyrhynchus granulatus Say (fig. 9) has been mistaken for the chinch bug in Ohio, and in a way that was somewhat amusing. Farmers in southern Ohio, during the winter of 1896–97, were burning over the woodlands with a view to destroying the hibernating insects, when there came several discouraging reports to the effect that such a course would be ineffective, as the bugs were wintering in the tops of trees, especially where the tops were dead, under the bark and often from 50 to 75 feet from the ground. This was a piece of astounding information, to the writer at least, and it was only after securing specimens that he was able to solve the mystery. This insect, in all stages of development except the egg, hibernates under loose bark. It is broader and much flatter than the true chinch bug, but the wings are white and the body black.

The object in calling attention to these bogus chinch bugs is to prevent their confusion with the true *Blissus leucopterus*, as in some cases people finding them and supposing them to be the true pest are likely to become panic stricken and often destroy property unnecessarily, so notorious has the name "chinch bug" become in the United States.

LOSSES CAUSED BY CHINCH BUGS.

It would appear that this pest first made its presence known by its ravages in the wheat fields of the North Carolina farmers; for we are told that "in 1785 the fields in this State were so overrun with them as to threaten a total destruction of the grain. And at length the crops were so destroyed in some districts that farmers were obliged to abandon the sowing of wheat. It was four or five years that they continued so numerous at this time." [a]

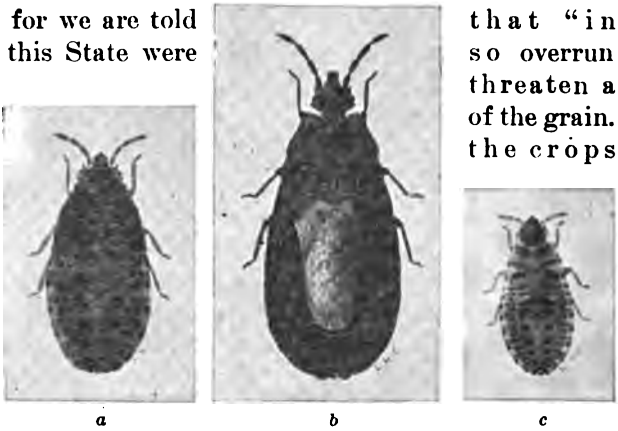

FIG. 9.—*Brachyrhynchus granulatus:* *a*, early nymph; *b*, adult; *c*, late nymph. All enlarged (original).

In the year 1809, as stated by Mr. J. W. Jefferys,[b] the chinch bug again became destructive in North Carolina to such an extent that in Orange County farmers were obliged to suspend the sowing of wheat for two years. In 1839 [c] the pest again became destructive in the Carolinas and in Virginia, where the bugs migrated from the wheat fields at harvest to the corn, and in 1840 there was a similar outbreak, and both wheat and corn were seriously injured. In all of these cases, however, there is no recorded estimate of the actual financial losses resulting from the attacks of the chinch bug. According to Le Baron, during the years from 1845 to 1850 the insect ravaged over Illinois and portions of Indiana and Wisconsin, and in 1854 and 1855 it again worked serious injury in northern Illinois. The writer's earliest recollection of the chinch bug and its ravages in the grain fields of the settlers on the prairies dates from this last outbreak. Mr. B. D. Walsh estimated the loss to the farmers of Illinois in 1850 at $4,000,000, or $4.70 to every man, woman, and child living in the State. The earlier outbreaks, though the occasion of smaller money loss, were even more disastrous; for the destruction of the grain crops in those pioneer days not only took away all cash profits, but also deprived the early settlers of their very living, and in some cases reduced them to starvation.

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[a] Webster on Pestilence, Vol. I, p. 279. Not seen. Quoted from Fitch.

[b] Albany Cultivator, first series, Vol. VI, p. 201.

[c] The Cultivator, Vol. VI, p. 103.

In 1863, 1864, and 1865 the insect was again destructive in Illinois and other Western States, its ravages being especially severe in 1864, when we have another attempt at computation of the financial loss. Dr. Henry Shimer, of Mount Carroll, Ill., who had carefully studied the chinch bug, estimated that "three-fourths of the wheat and one-half of the corn crop were destroyed by the pest throughout many extensive districts, comprising almost the entire Northwest." In criticising the doctor regarding another point, Messrs. Walsh and Riley, in The American Entomologist (Vol. I, p. 197, 1869), admit that the estimate was "a reasonable one," and, taking it as a basis, with the actual cash price per bushel, computed the loss at about 30,000,000 bushels of wheat and 138,000,000 bushels of corn, with a total value of both amounting to over $73,000,000. Of course all computations of this sort are necessarily only approximately correct, but there is more likelihood of an under than an over estimate in this case.

There was a serious outbreak of the chinch bug in the West again, in the year 1868, and again in 1871, but in 1874 the ravages were both widespread and enormous. Doctor LeBaron computed the loss in 1871 in seven States, viz, Iowa, Missouri, Illinois, Kansas, Nebraska, Wisconsin, and Indiana, at $30,000,000.[a] Doctor Riley computed the loss in Missouri alone in the year 1874 at $19,000,000, and added the statement that for the area covered by Doctor LeBaron's estimates in 1871 the loss in 1874 might safely be put down as double, or upward of $60,000,000.[b] Dr. Cyrus Thomas, however, estimates the loss to the whole country for the same year at upward of $100,000,000.[c]

The next serious outbreak of the chinch bug of which we have the losses resulting therefrom computed, occurred in 1887, and covered more or less territory in the States of Kentucky, Ohio, Indiana,

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[a] Second Report State Entomologist of Illinois, p. 144.

[b] Seventh Report State Entomologist of Missouri, pp. 24–25

[c] Bulletin No. 5, U. S. Entomological Commission, p. 7.

Illinois, Wisconsin, Minnesota, Iowa, Missouri, and Kansas. In this case the damage was estimated by the United States statistician, Mr. J. R. Dodge, at $60,000,000, the heaviest losses occurring in Illinois, Iowa, Missouri, and Kansas.[d] This gives us as the estimated loss in the thirty-eight years, 1850 to 1887, both inclusive, the enormous sum of $267,000,000.

There was a serious outbreak in Kansas, Iowa, Minnesota, and Illinois, having its beginning probably as early as 1892, but reaching its maximum severity, as in Ohio, in 1896. The loss in Ohio during the years 1894, 1895, 1896, and 1897 could not have fallen far short of $2,000,000. The farmers of this State in many cases were entirely unfamiliar with the chinch bug and its ravages, and therefore were unable to account for the damage that it worked in their fields until some time after. This was especially true of the timothy meadows in the northeastern part of the State; so that there were probably many fields, both of grass and of grain, that suffered seriously, and, in fact, in some cases were ruined by the chinch bug without the owners being aware of the cause. For this reason, while the computed loss appears large, it seems to me to be entirely reasonable. Of the losses occasioned in other States during the years above indicated no definite computations are available, but they were severe, and must have amounted to millions of dollars. If we could have careful estimates of the loss during the last fifteen years, it would in all probability

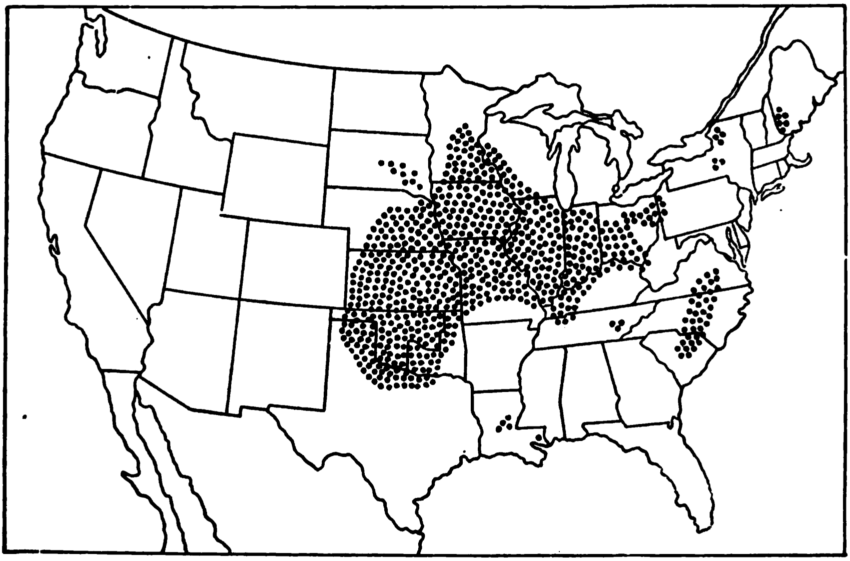

FIG. 10.—Map showing areas in the United States over which the chinch bug occurs in greatest abundance and may at any time become destructive. (Original.)

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[d] Report of U. S. Commissioner of Agriculture, 1887, p. 56.

swell the amount to considerably in excess of $330,000,000 for the period from 1850 to 1906. Within the last ten years the insect has become more injurious in Oklahoma, western Kansas, and northern Texas, localities not included in these estimates, and although the spring rains serve to destroy the young bugs, outbreaks in northern Texas and Oklahoma are not rare in fields of wheat, corn, and barley. If the indirect losses were to be added, the amount would indeed be enormous. During the outbreak in Ohio at least two farmers became discouraged, and, thinking that the loss of their crops by the attack of chinch bugs would result in their financial ruin, in their despondency they sought relief in suicide.

When we take into consideration that the financial losses as above estimated have not fallen upon the entire nation, but almost without exception upon the nine States previously named (see fig. 10), it will be seen that this diminutive insect constitutes a formidable enemy to the agriculturist of these States. In fact, small as it is, this pest has cost the people of these nine States a sum of money which, a few years ago, would have defrayed the entire expense of the National Government for a whole year. Fire excepted, there is probably no other factor that has caused such an enormous financial loss within the same period over the same area of country.

NATURAL CHECKS.

All adverse natural influences affecting the chinch bug will be treated under this head, with the exception of animal and vegetable foes, which are considered here as natural enemies.

INFLUENCE OF PRECIPITATION ON THE CHINCH BUG.

There is probably no more potent factor in restraining the increase in numbers of this species than is to be found in meteorological influences consequent upon rain. The fact has long been known that the years of greatest abundance of the chinch bug were preceded by a series of years during which there had been a deficiency in the rainfall over the area of country devastated by this species. In fact, it has in a general way come to be understood that dry seasons are favorable and wet seasons unfavorable for the development of the chinch bug, though the details of the phenomenon have never been very carefully and elaborately worked out. The entomological and meteorological records of the past have, however, clearly shown that the amount of the annual rainfall is not a safe guide in this problem. Chinch bugs have occurred in excessive numbers during years of heavy precipitation.

The term " wet season," so frequently used in this connection, is an indefinite one, but if the term " season " be restricted to the period of time intervening between the vernal and autumnal equinoxes we shall have more definite grounds upon which to base our studies of meteorological influences. Thus applied, the terms "wet" and "dry" seasons would include within them the two breeding periods of the chinch bug, at least largely so, north of latitude 30° N. But the history of this species has shown that there may be an excess of rainfall during this critical period and that still a sufficient number of insects may develop to work serious injury over considerable areas of country. This is due to two, and perhaps more, causes. In the first place, an unusually heavy rainfall at long intervals, while bringing up the total for a given period, may have but little effect in reducing the number of chinch bugs, while a much less amount of precipitation coming at short intervals and in the midst of the hatching season would cause a far greater mortality among the young. And, in the second place, the precipitation may come at the beginning or even

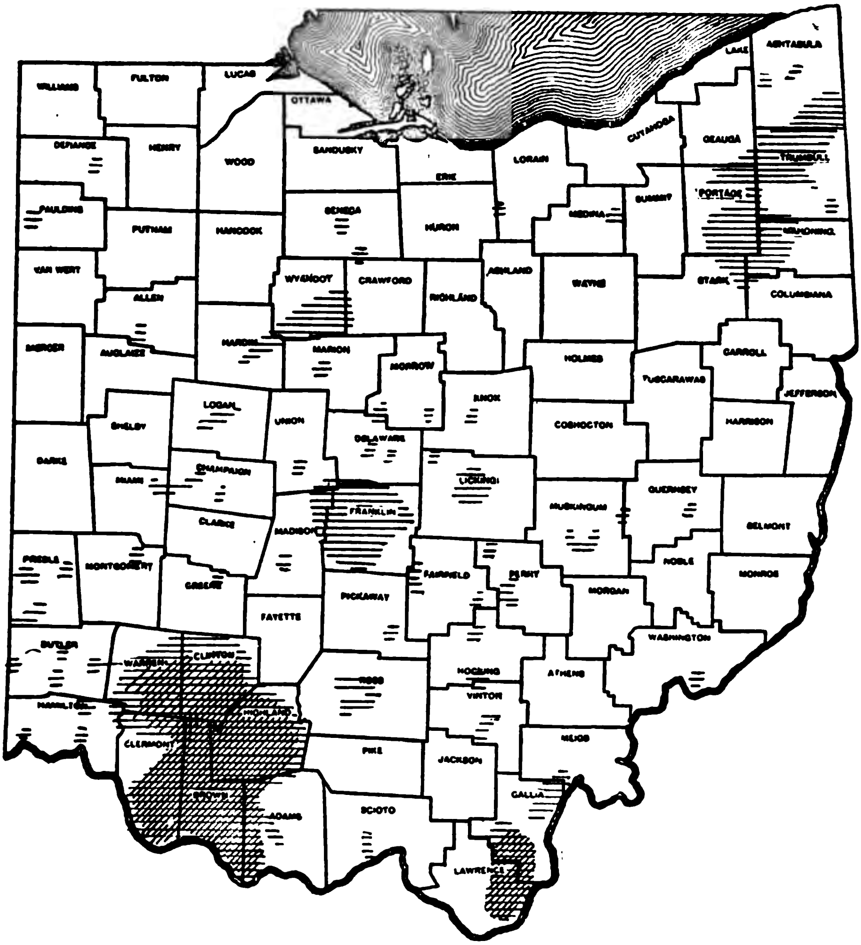

FIG. 11.—Map showing distribution of chinch bug in Ohio in 1896. (Author's illustration.)

before the commencement of this breeding season or just at the close thereof, thus enabling the major portion of the young to reach a period in their development wherein they are little, if at all, susceptible to the effects of drenching rains. This was clearly illustrated in southern Ohio during the spring of 1896, and again in 1897. Throughout southern Ohio, in 1896, between latitude 38° 30′ and 39° 40′, as the reports of the United States Weather Bureau show, there had been but very little rain up to May 11, and no general rain until May 25. The effect upon the young bugs, judging from the destruction which they caused, would seem to have been to destroy only the latest to hatch, leaving the earlier developing young sufficiently advanced to withstand the effects of the later and heavier rains. The accompanying map (fig. 11) will show the areas over which chinch bugs were reported marked thus ▤, while the

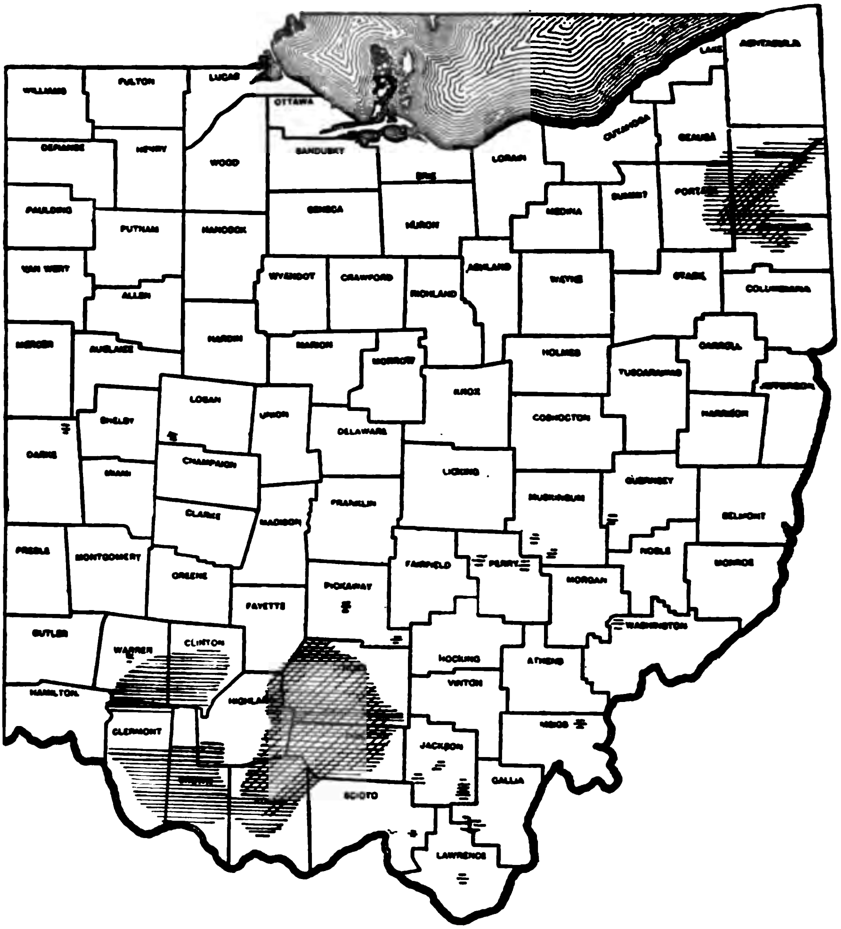

FIG. 12.—Map showing distribution of chinch bug in Ohio in 1907. (Author's illustration.)

area seriously ravaged is indicated thus #, showing that the rain came too late in such a section to ward off an outbreak of the pest.

According to the Weather Bureau reports also, the distribution of rain in May, 1897, differed materially from that of the same month of 1896, in that in 1897 the major portion of the rain fell prior to the 15th, the remainder of the month being rather dry, the only general precipitation occurring on the 23d and 24th, with a much lighter rain on the 28th. But here again the amount was insufficient to ward off serious injury, as is indicated by map (fig. 12), the same symbols being used here as before. In this case it was probably the latter portion of the brood that survived, as a personal inspection of the country early in the month failed to reveal the presence of young bugs, though they were certainly present in abundance at a corresponding period of the preceding year.

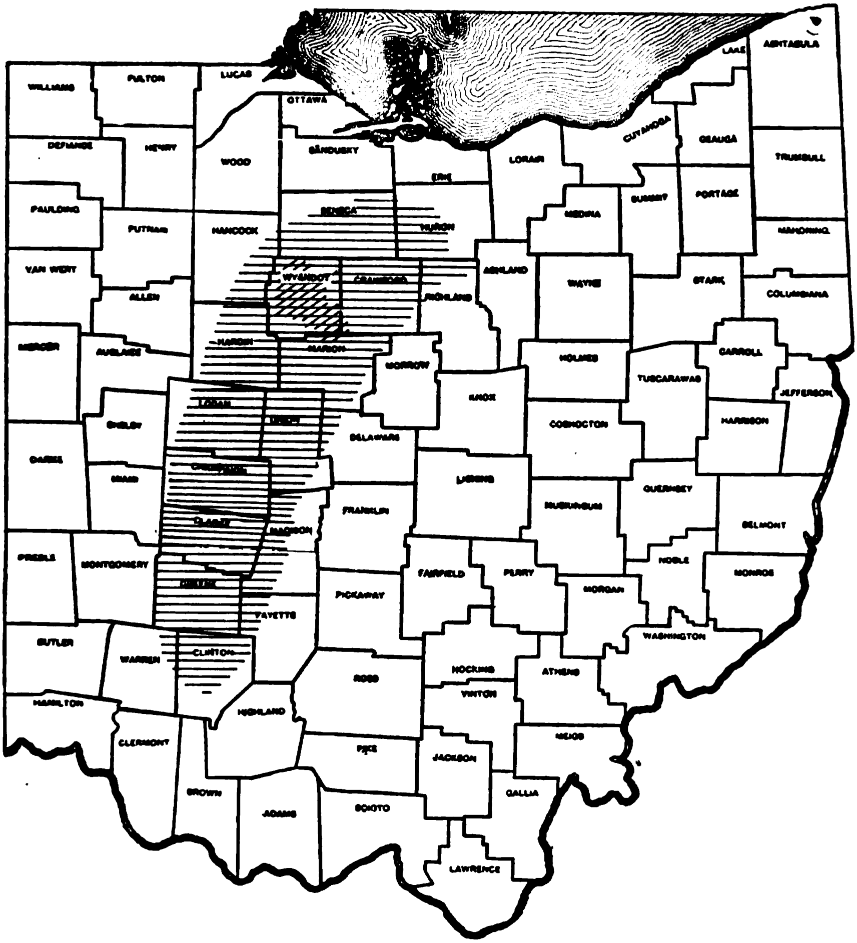

FIG. 13.—Map showing distribution of chinch bug in Ohio in 1894. (Author's illustration.)

That the amount and frequency of rain during the month of May has very much to do with the ravages of chinch bugs where sufficient numbers have wintered over to produce the requisite number of young, is further shown by the fact that in 1894 the only locality where serious ravages were committed was in Wyandot County, as shown on map (fig. 13), and this was one of the few areas in Ohio where the precipitation during that month was less than 3 inches.

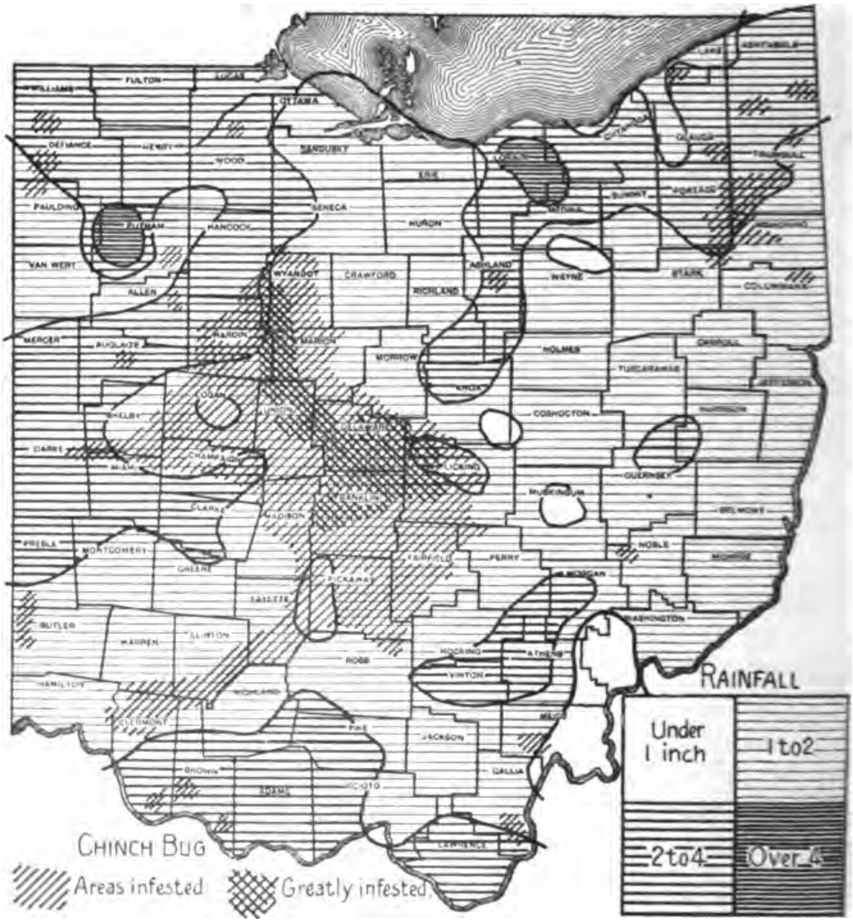

FIG. 14.—Map showing distribution of chinch bug in Ohio in 1895, and amount of precipitation over the State during May of the same year. (Author's illustration.)

Except over a circular area covering less than one-half of the county the amount of precipitation was 3 to 5 inches, and this area includes that ravaged by the chinch bugs during the following month.

Still more striking, however, is the relation between the two phenomena during the following year. The last of this series of maps (fig. 14) shows the area over which chinch bugs were reported and the area where their injuries were the most severe; also, by horizontal lines, the areas over which the amount of precipitation was the least. From this it will be observed that in all of the seriously affected area, and in nearly all of the area over which the pest was reported at all, the precipitation during the month of May, 1895, was from 1 to 2 inches, the extension of the point westward into Shelby County being especially interesting. It may be said with regard to the occurrences outside of this area of light precipitation that the exact localities were probably not indicated, as the information was secured from farmers, and their locations as indicated on the map were their post-office addresses, which might have been several miles away in any direction, and the isolated points of attack were often based upon one or two reports. If exact localities could have been obtained, and the precise area of precipitation indicated, the connection between the two phenomena would have been shown more correctly, and would probably have revealed an even greater uniformity than is now apparent. It must be understood, however, that in these calculations northeastern Ohio is excluded, and the writer believes that what is true of the rest of the State will be found to be equally correct as regarding territory occupying the same latitude westward to the limit of this area of distribution. While it is probable that the effect of precipitation during August would have a similar influence on the second brood of young, and, consequently, upon the number of adults which would go into winter quarters, yet a careful study of the two factors shows that meteorological conditions in August have a far less influence upon the following brood than do those of May.

Owing to causes which are as yet unknown to the writer the same laws do not apply to the northeastern part of Ohio and to what we have termed the west-bound tide of migration. Here, and as against the more or less short-winged form of chinch bug, meteorological conditions appear to exert a far less potent influence. What is true of meteorological conditions during May elsewhere in Ohio, seems to be partly true of June in the northeastern portion of the State, though there is not the evidence of the effect of precipitation here that we have elsewhere. Doctor Lintner, in his Second Report, while discussing the outbreak of the chinch bug in New York during 1882–83, calls attention to the fact that both in 1881 and 1882 there was an excess of precipitation. On page 158 of his report Doctor Lintner says that spring, summer, and autumn were exceptionally wet. In spring heavy and continued rains flooded meadows which, later, showed the effect of chinch-bug attack. Even at haying time while the bugs were young and, according to all accounts, easily killed by heavy rains, they persisted in multiplying and living despite the fact that rains were so frequent and severe that only a portion of the hay could be gathered in a proper condition. This was the state of affairs on July 5 when the hay was cut, and on October 10 Doctor Lintner stated that owing to continued rains grass was still lying in the fields and could not be gathered, while fields of oats remained unharvested. In all of the reports given of this outbreak it was stated that the damage was first observed in August or September, and it is believed that this will hold good as applied to northeastern Ohio.

As has been stated, the females oviposit as a rule at or just below the surface of the ground, and the young make their way upward in order to secure food. In case of cultivated grains this mode of procedure is absolutely imperative, as the bases of the plants are at that time too tough and woody to offer sufficient food. But in the case of timothy the conditions are entirely different, as the bulb of this plant, situated just below the surface of the ground and convenient to the place of oviposition, furnishes an ample supply of food without making it necessary for the young to crawl upward in order to secure it. Then, too, the surface of the ground in cultivated fields is nearly or quite free of dead leaves and stems, there being little but the vertical-growing plants to afford protection from the weather. In timothy meadows the surface of the ground is usually covered to the depth of an inch or more with dead and decaying stubble and leaves, and the top of the ground itself is often more or less loose and mellow in the immediate proximity to the bulbs of the plants. It would appear that we might here have a partial solution of the problem of the vital effects of precipitation on the young bugs. Besides, for aught we know, the progeny of this quite short-winged form may be better able to withstand naturally the effect of drenching rains than that of the east-bound long-winged form. We must recollect that in the one case the progenitors have worked their way over hot, arid plains as well as cool, damp prairies, while in the other case the tide of migration lay between the more elevated lands and the sandy beaches of the seashore where there was always a more or less near proximity to the ocean, until the tide of migration left the seashore and drifted westward over New York and onward into northeastern Ohio. (See map, fig. 17.)

This influence of precipitation on the young chinch bugs while in the act of hatching, and that of temperature upon the adults in winter, some illustrations of which have been included under the subject of hibernation, are the only cases where meteorological conditions appear to have a direct effect on this species. As previously shown, the temperature effects are, largely at least, unfavorable for such adults as may happen to be more or less unprotected during the hibernating season. Upon this point it might be well to suggest that this protection, which may be composed of leaves and dried grass, may be burned away in early winter and thus leave the insects without the expected protective covering, or this covering may be still further augmented by a mantle of snow, which, remaining for a more or less protracted period of time, counteracts the influences of temperature, and the latter then becomes a factor of secondary importance in the problem of life among chinch bugs. It is very doubtful if temperature is as vital in its effects as are the indirect influences of precipitation during the breeding season.

It has long been understood that the two species of entomogenous fungi, *Sporotrichum globuliferum* Speg. and *Entomophthora aphidis* Hoffm., both of which attack the chinch bug, require for their rapid development an atmosphere heavily charged with moisture, and that without this neither of these becomes sufficiently abundant to cause any serious mortality among the insect host, but this matter will receive attention in the discussion of these parasitic foes farther on.

INFLUENCE OF TEMPERATURE ON THE CHINCH BUG.

The writer would call attention here to a possible influence of temperature upon what he has termed the west-bound tide of migration. When the time arrives for the hibernating adults to leave their winter quarters and disperse over the fields prior to oviposition, if the weather should prove too severe they have but to remain in these quarters a while longer until more favorable weather. Thus, along the northern Atlantic coast the season is generally much later near the shore than it is a few miles inland, and Mr. Schwarz[a] has called attention to the influence which this phenomenon exerts upon the chinch bug. Now, this retardation amounts probably to about a month in spring, which would have a tendency to delay oviposition, especially among the short-winged females. If this were continued through a long period of time, consequent upon the slow movement of this tide of migration northward along the coast, it would hardly be surprising to find that this retarded activity in spring had become so characteristic as to be retained after this tide had swept to the westward, and resulted in the species being thus single brooded in the East, while it is double brooded in the east-bound tide of migration in the West. This effect of a long habitation along the shores of the northern Atlantic would be to some extent encouraged by the prolonged northern winter and the correspondingly shorter period during which the species could breed, and thus instead of the effects of the old environment becoming obliterated they might be continued, or, as in case of the fore-shortening of the wings, still further intensified. If the effect of this prolonged period of hibernation has been to reduce the number of broods, then it will have to be considered as a natural check, in that to a certain extent it prevents excessive abundance by reducing the number of offspring. This would also account for the rather surprising immunity that has heretofore been enjoyed by the northeastern portion of the country from the ravages of this destructive species.

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[a] Insect Life, Vol. VII, p. 422.

NATURAL ENEMIES.

It is possible that there are some reasons which might appear to justify the placing of fungous enemies of the chinch bug among the natural checks, as they no doubt do exert a more or less powerful influence in that direction, but it seems more convenient to include them among natural enemies, especially as one at least has come to be applied artificially to overcome the insect. The fact that the abundance and consequent influence of these fungous enemies is almost entirely dependent upon meteorological conditions is sufficient to place them in a secondary position, even though they may under favorable meteorological conditions act as natural checks. All, doubtless, have other host insects, and the two most important have been known to break out again and again spontaneously and destroy myriads of chinch bugs when the latter were present in excessive numbers. But this has taken place only in connection with the necessary precipitation; hence these fungi become natural enemies only under certain favorable weather conditions; and though their season of most potent effect is during the time when the chinch bug is developing from the egg to the adult, yet as shown by observation they may exert powerful and fatal effects among the adults, where these last have congregated together in masses.

PARASITIC FUNGI.

The two species of entomogenous fungi to which reference has just been made are *Entomophthora aphidis* Hoffman[a] and *Sporotrichum globuliferum* Speg,[b] both having probably been associated in destroying the chinch bug spontaneously in the fields, and doubtless were distributed to correspondents by Professor Snow and others to be artificially established in fields where there was an overabundance of chinch bugs. For this reason it is impossible to separate the effects of the two in the earlier literature, even the first observations of Dr. Henry Shimer[c] probably applying to their joint effect.

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[a] Hoffman, in Fresenius's "Entomophthoreæ," p. 208, figs. 59–67.

[b] Spegazzini, "Fungi Argentini," II, p. 42.

[c] Proc. Acad. Nat. Sci. Phila., May, 1867.

Doctor Shimer, however, was the first to call attention to the widespread and fatal effects of fungous diseases among chinch bugs, and while his explanations therefor seem now crude and illogical, his observations were made with such care and accuracy that we have not yet had occasion to materially revise them. Under date of July 16, 1865, he makes this observation: "* * * I found many dying on the low creek bottom land from the effects of some disease, while they are yet in the larval state—a remarkable and rare phenomenon for insects thus in such a wholesale manner to be dying without attaining their maturity, and no insect enemy or other efficient cause to be observed capable of producing this important result." Again, under date of July 22: "On low grounds the chinch bugs are dead from the disease above alluded to, and the same disease is spreading to the hills and high prairies."

Under this date also he speaks of the very wet weather, and states that in a barley field the chinch bugs began to die at about the same time that they did on the low creek bottom, and that they rapidly met the same fate, so that few of them lived to find their way to a neighboring cornfield, while under date of August 8 he states that of those that migrated to the cornfields "very few are to be found remaining alive; but the ground around the base of the cornhills is almost literally covered with their mouldering, decomposing dead bodies. They are dead everywhere, not lying on the ground alone, but sticking to the blades and stalks of corn in great numbers, in all stages of development, larva, pupa, and imago."

"This disease among the chinch bugs was associated with the long-continued wet, cloudy, cool weather that prevailed during a greater portion of the period of their development. * * *"

These are precisely the conditions under which these fungi have been observed to prove the most fatal to the chinch bug during recent years, where their introduction among the host insects was accomplished by artificial means. Although Doctor Shimer probably never anticipated the artificial cultivation of his "disease," and the results which have since been obtained from its artificial dissemination in the fields, yet his careful and painstaking studies must ever be associated with the application of fungous diseases in the destruction of insects in America. It is certainly to be regretted that such practical entomologists as Mr. B. D. Walsh and Dr. C. V. Riley should have expressed themselves so discouragingly regarding Doctor Shimer's observations and conclusions, Doctor Riley, as late as 1870, even going so far as to ridicule the theory of disease being in any way responsible for the death of the chinch bugs observed by Doctor Shimer.[a]

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[a] Second Report State Entomologist of Missouri, pp. 24–25, 1870.

It was not until 1879 that an entomologist came to the rescue of Doctor Shimer's theory of disease among chinch bugs. Dr. Cyrus Thomas, in Bulletin No. 5 of the United States Entomological Commission, 1879, page 24, stated that while Doctor Shimer's plague among chinch bugs was somewhat extraordinary, yet it was in accordance with facts that he had himself ascertained in reference to other insects, and in proof he cited a similar wholesale destruction of flies in southwestern Virginia and eastern Tennessee in the year 1849, and also a similar epidemic among grasshoppers in western Minnesota, Dakota, and northern Iowa in 1872. This position of Doctor Thomas in support of Doctor Shimer may be regarded as a second step in our advance in a knowledge of the influence of meteorological conditions on the chinch bug. It paved the way for further research in this direction.

FUNGOUS ENEMIES OF THE CHINCH BUG DETERMINED.

While the subject of epidemic and contagious diseases of insects was discussed to a greater or less extent among scientific men, there was a decided lack of actual experimentation, and none at all with the fungous parasites of the chinch bug until 1882 and 1883, when Prof. S. A. Forbes began what ultimately proved to be a long series of studies of the chinch bug and its natural enemies. At this time, 1882, Professor Forbes was more especially interested in the bacterial diseases of the chinch bug, and though he found, at Jacksonville, Ill., many specimens of dead chinch bugs embedded in a dense mat of white fungous threads, which sometimes almost hid the body and reminded him of the fatal disease previously reported by Doctor Shimer, yet except to secure from Prof. T. J. Burrill a determination of this fungus as belonging to the Entomophthora no progress was made in the study of this particular phase of the chinch-bug problem.[a]

In July, 1887, Professor Forbes found attacking the chinch bug in Clinton County, Ill., a second fungus, which he determined as belonging to the genus Botrytis, but this conclusion has since been revised and the species is now known as *Sporotrichum globuliferum* Speg. This discovery of a second species of entomogenous fungi and its separation from the Entomophthora comprises what may be justly termed a third step in the advancement of our knowledge of this problem. Professor Forbes, however, seems to have still been too deeply interested in his bacterial studies to pay any special attention to the other phases of his problem, further than to record the occurrence of his new Botrytis in various localities in Illinois, and in one instance on a beetle, *Parandra brunnea* (observed by Mr. John Marten, at Champaign), and, similarly, to note the occurrence of the still specifically undetermined Entomophthora.[b]

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[a] Twelfth Report of the State Entomologist of Illinois, pp. 47–51, 1882.

[b] Sixteenth Report of the State Entomologist of Illinois, pp. 46–49, 1888.

The scene of action now changes from Illinois to Kansas, and to Prof. F. H. Snow belongs the credit of first applying the knowledge that had been gained up to that time (1889) by confining supposed healthy chinch bugs with others affected by either one or the other of the fungi, or possibly both Entomophthora and Sporotrichum, and using the bugs thus infected for the propagation, in the field, of the disease from which they had died.

As early as 1887-88 Professor Snow expressed, in the Sixth Biennial Report of the Kansas State Board of Agriculture, the opinion that "in the warfare of man against his insect foes a most valuable ally will be found in the bacterial and fungoid diseases which may be artificially introduced when nature fails to come to our aid," an opinion at that time largely based upon the investigations of Professor Forbes and his own observations of the chinch bug in Kansas, thus paving the way for the experiments of 1889. Professor Snow had now obtained a specific determination of the fungous disease as (*Empusa*) *Entomophthora aphidis* Hoffman, although there is some ground for the suspicion that *Sporotrichum globuliferum* was also present.

Entomophthora aphidis was already known to affect Hemiptera in Germany and the United States. Dr. Roland Thaxter[a] states that, as early as 1886, his attention had been called to the attacks of this fungus on aphides in the greenhouses at Cambridge, Mass., where it acted as a decided check, and later, in 1887, Dr. L. O. Howard had called his attention to great quantities of aphides dying with the same disease on clover near the Agricultural Department buildings in Washington, D. C.

FIELD AND LABORATORY EXPERIMENTS IN INDIANA.

On July 20, 1889, the writer, at that time a special agent of the Division of Entomology of the United States Department of Agriculture, stationed at Lafayette, Ind., received, through the kindness of Professor Snow, enough material with which to make some experiments, the chinch bug being at that time very abundant at Lafayette, and an exceptionally good opportunity thus being offered for experimentation. The results of these experiments were published in detail in Bulletin 22 (old series), United States Department of Agriculture, Division of Entomology (pp. 55-63), but as this was the first series of experiments carried out with a view of testing with exactness the precise effects of varying degrees of temperature and atmospheric moisture on the growth of the Entomophthora, and carefully following out the progress of the disease under varying meteorological conditions, the matter is here republished in full, the bulletin in which it was originally included being now out of print.

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[a] Memoirs Boston Society of Natural History, Vol. IV, p. 176.

These diseased bugs were placed under glass with living ones from the fields, the latter being provided with food and kept thus confined for fifty-three hours, when the major portion of them were placed on several hills of corn seriously infested by bugs, the remainder with the dried remains received from Professor Snow being scattered about over a small area of young wheat sown for experiment and also swarming with young chinch bugs. The hills of corn on which the bugs had been placed were isolated from others, equally badly infested, by narrow frames of boards placed on the ground and the upper edges covered with tar. This last precaution was taken in order to prevent communication with other hills, intended as checks on those used directly in the experiment. The area of young wheat over which infested bugs had been placed was not inclosed, but its limits carefully marked. Five days after, July 27, a single bug was found on one of the isolated hills of corn which had very evidently died from the effects of Entomophthora, and by the 30th enough others were found to show that the fungus had fully established itself and the barriers about the isolated hills were removed. On August 2 dead bugs covered with Entomophthora were found in considerable numbers about hills of corn 25 feet from where the original colonies had been placed and also throughout and even 55 feet beyond the area of young wheat over which dead and affected bugs had been distributed. Daily observations were now made, but the progress of the disease seemed to come to a standstill. From the 5th of August up to the 9th it was almost impossible to get sufficient material outside to enable me to carry on laboratory experiments. August 13 the spread of Entomophthora appeared to have taken on new life, and diseased bugs were becoming much more numerous. August 15 found diseased bugs 172 feet from any place where they had been previously observed. August 20 diseased bugs were very abundant over all of the area where disease had been distributed, and two days later examples were found a quarter of a mile from the starting point of the disease. Immediately after this, however, another halt was observed, both in the intensity of attack and rapidity with which it spread, due either to the dry weather or to the fact that the bugs had now all reached the adult stage and had become diffused over the country, no longer congregating together. From either one or the other, or both of these causes, I lost track of the Entomophthora and was not able to again find it in the fields. It seems proper to state here that chinch bugs were not at any time excessively abundant. The greatest numbers were in the exact localities where the disease was first distributed, the congregating at these places being brought about by the close proximity to a large number of small experimental plats of wheat, and when this was harvested the bugs collected *en masse* on the corn and young wheat. In connection with these facts, it is also interesting to note that from July 15 to August 31 there were ten days on which rain fell. The dates of these rains and the amount of precipitation is given below:

Date.	Precipitation.	Date.	Precipitation.
	Inches.		*Inches.*
July 17	0.02	July 29	[illegible]
19	1.25	30	[illegible]
22	.20	Aug. 9	[illegible]
23	.04	13	[illegible]
26	.13	14	[illegible]

With a view of learning whether or not there was any difference as regards susceptibility to the attack of Entomophthora between bugs in different stages of development, a series of experiments was begun, as follows:

Young plants of *Setaria glauca* were transplanted to a box, and upon each plant was placed a dead bug covered with the fungus, and also healthy larvæ; larvæ just on the point of pupation; pupæ just prior to reaching the adult stage, and fully developed adults, each stage being placed on separate plants, and each covered with a small inverted glass vial designated by lettering. As checks, another series was prepared, like the first in every particular. The soil in the box was kept well moistened, and the plants remained fresh. This experiment was made on August 2, about the time when the attack outside began to diminish in intensity. The following are the results of examinations on the dates indicated, the original experiments being indicated by capitals and the checks by small letters, thus—A–a, adult; B–b, young larvæ; C–c, older larvæ; D–d, pupæ.

Date.	A.	a.	B.	b.	C.	c.	D.	d.
Aug. 5	Healthy ..	Healthy ..	Healthy ..	Healthy ..	1 dead....	Healthy .	1 dead ...	1 dead.
Aug. 6	1 dead	1 dead....	Healthy ..	Healthy ..	1 dead....	Healthy .	3 dead ...	1 dead.
Aug. 7	All dead..	3 dead....	3 dead....	1 dead	3 dead....	1 dead ...	....	5 dead.
Aug. 16	All dead..	All dead..	All dead..	All dead..	All dead..	All dead.	All dead.	All dead.

On the same day this experiment was begun a second was also commenced, like the first in every particular, except that the healthy bugs used in experimentation were exposed to fungus-infected individuals for only five hours and then placed under their respective glasses. As a result, on August 15, thirteen days after, none had died, thus strongly indicating that the Entomophthora did not exist generally in the fields, and that it could not be communicated during a period of five hours' exposure.

On August 7 a large number of healthy bugs were placed under glass, with a number which had recently died from Entomophthora, the moisture in the vessel being absorbed by calcium chloride. A check experiment was also commenced, where the material and the conditions were the same, except the humidity of the atmosphere, care being taken to have the latter as nearly saturated with moisture as possible. August 10 the original experiment was divided and a portion of the healthy bugs removed and placed in a damp environment, the remainder being kept under the original dry conditions. The results on August 22 were as follows: In the original experiment, where the healthy bugs had been continually in dry quarters, not a single bug had died from Entomophthora. Not only this, but none of those which had been removed after three days and placed in dry quarters had died, showing that the disease was not contracted and did not develop in healthy bugs, though kept exposed in a dry atmosphere for fifteen days, nor could it be originated by placing in a damp atmosphere for twelve days bugs which had been exposed to contagion for three days in dry quarters. The results with the check experiment were quite different. Within five days after being confined with the Entomophthora the healthy bugs began to die from effects of the disease, and in three days more every one had died from the same cause, their bodies being covered with spores.

Still another experiment was tried, which consisted in confining a large number of healthy bugs with others diseased in a damp environment, and when the fungus had destroyed a portion the remainder were divided and a part removed to dry quarters. The result was that while those left in damp confinement continued to die, none of those inclosed in dry environment were destroyed. As the fungus had by this time become distributed over the experiment farm so that I could not tell with certainty whether material from the fields was in a perfectly healthy condition or not, no further experiments were made in this direction.

From the foregoing it will be observed that the essential element in all of these experiments was an abundance of moisture, without which the Entomophthora could neither become established nor flourish after it had gained a footing. Again, the extent to which the disease will prove contagious will depend upon the number of bugs. Without great numbers massed together comparatively few would contract the disease. To sum up the matter, there is little hope for relief to the farmer from the influence of Entomophthora, except when chinch bugs are abundant and massed together in great numbers, and during a period of wet weather. I have succeeded in getting the fungus established at two widely located points in Indiana, and do not consider it at all difficult to introduce in localities where chinch bugs are abundant, provided the weather is favorable. But if it is ever utilized by the farmer, which seems to me to be at present a matter of considerable doubt, it will only be after the pest has become very abundant, during the time between the first larval and adult stages and in a wet time. After the Entomophthora has been introduced into a certain field it will become diffused only in proportion as the bugs travel about and healthy bugs come in contact with spores from those which have died from the disease. This will not be very great until the pupal stage is reached.

The larvæ of chinch bugs seem to in some way understand that while molting they will be well-nigh helpless, and hence hide themselves away in vast numbers in secluded places. Under such conditions the spores thrown from diseased bugs would reach a larger number of their fellows. I have found adults but recently molted affected by the Entomophthora. After the bugs acquire wings and scatter themselves over the country, the liability to contagion will be again reduced, unless in case of very severe invasions, where, from force of numbers, congregating on or about food plants becomes a necessity. Hence the introduction of the fungus among larvæ will at first proceed but slowly, and only in extreme cases and under favorable conditions can it be expected to proceed much more rapidly among adult bugs. In short, the only way that this fungoid disease seems capable of being employed in agriculture is by the establishment of some central propagating station to which farmers can apply and receive an abundant supply of infected bugs on short notice. By this means they could take advantage of a rainy period of a week or ten days, and, if they can contrive by sowing plats of millet and Hungarian to mass the bugs in certain localities about their fields, they might accomplish something toward warding off an invasion. But the possibility of overcoming an invasion after it is fully under way, as is almost sure to be the case during a dry season, it must be confessed is not very encouraging. My failure after repeated experiments to produce this Entomophthora in the vicinity of Lafayette without the importation of germs is decidedly against the theory that might be advanced that the northeastern portion of the State was kept free of destructive invasions by reason of this disease brought about by wet weather. There is as yet no reason to believe that the disease has ever existed in that section of the State.

The fungus entering into these experiments was determined as an Entomophthora by Dr. J. C. Arthur, and the probability is that it was *E. aphidis*, though it is possible that Sporotrichum was also present and remained unobserved.

FIRST FIELD APPLICATIONS OF FUNGOUS ENEMIES OF THE CHINCH BUG.

As has been stated, the credit for first confining healthy chinch bugs with those diseased and utilizing the individuals thus infected by transporting them to sections of the country supposedly free from the disease in order to create new areas of infection, belongs to Prof. F. H. Snow. During October, 1888, the year prior to that during which Professor Snow began his experiments, Prof. Otto Lugger, of Minnesota, collected a quantity of diseased chinch bugs at the experiment station at St. Anthony Park and distributed them to eighteen different localities in the southern part of the State where the pest was known to occur in destructive abundance. The diseased material was sent out in tin boxes by mail, and the contents of the boxes, on arrival at their destination, were simply thrown in any field where there was an abundance of chinch bugs. Later in the season the condition of affairs where these distributions had been made was such that "careful search in the majority of places failed to produce a single living specimen, while the traces of the disease were found everywhere." With a spirit of caution and exactness in every way most commendable on the part of Professor Lugger, he says: "The disease spread so rapidly that even corn growing near wheat fields crowded with chinch bugs was entirely protected, and no bugs had entered it in all the places visited by myself. But the writer is by no means satisfied that the disease was really introduced in this manner. Is it not possible that the disease was already there, unknown to anyone, and that the writer had simply reintroduced its germs? The reason for this belief is based upon the fact that too large an area was infested by the disease—too large to be readily accounted for by the short time in which the atmospheric conditions were apparently in its favor."[a]

In this case Professor Lugger states that both Entomophthora and Sporotrichum were present and the latter was sent by him to Professor Forbes, so there is the same confusion of the two fungi in this case that existed in the writer's experiments in Indiana, except that in the one case it was certain that Entomophthora was present, while in the other it was the Sporotrichum.

THE WORK OF PROFESSOR SNOW IN KANSAS.

Although Professor Snow had the experience and observations of Shimer, Forbes, and Lugger to aid him in his first efforts to apply the knowledge gained by these gentlemen, yet it must be said that it has been largely due to his untiring energy and perseverance that the use of these fungi has reached the present state of importance. It will hardly be saying too much if we state that his persistent undaunted labors, in the face of much skepticism and opposition, has won for him the admiration of his fellow-workers, even among those who were long in extreme doubt as to the success of his labor. He has done more than any other one person to call attention to the possibilities of practical benefits to be derived by farmers themselves; has done more to advertise the merits of these fungous diseases among the masses than anyone else, and, in fact, has made the "chinch-bug fungus" almost a household word over the entire United States.

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[a] University of Minnesota Experiment Sta., Bul. 4, Oct., 1888, pp. 40–41.

It is therefore all the more to be lamented that he should have accepted and published in his several reports the unsubstantiated statements of farmers whose testimony on a matter of this nature is, as every entomologist knows, absolutely worthless unless accompanied by specimens. His own personal experience in this direction and in several States had long ago led the writer to disregard all reports relating to the efficiency or inefficiency of these fungous diseases among chinch bugs, when such came from the ordinary farmer without being accompanied by specimens for examination. The cast pupal skins of the chinch bug pass with nonentomologists very well for dead bugs, and if the former have been attacked by the ordinary white molds the deception, except to the eye of an expert, is complete.

There is probably not an entomologist who has distributed these fungous diseases among farmers who has not found just such conditions as did Professor Lugger in Minnesota, where it was impossible to determine whether these diseases had been introduced artificially or whether they were already present and had been overlooked. In the writer's experience, while receiving chinch bugs from different parts of Ohio to be infected with the disease, consignments have come to him with the insects dying and others dead and covered with Sporotrichum, showing that this was already present and that the very utmost that we could expect to accomplish would be to aid in locally spreading the contagion. Besides this, the writer has sent material to farmers sufficient to start the fungus in their fields, knowing perfectly well that it would be a considerable time before actual benefits could by any possibility be expected to materialize, and within a week received the astonishing information that the fungus was so perfectly successful that the bugs all disappeared within a few days after the application of the disease. There is little doubt that the distribution of upward of 7,000 boxes of these fungi to the farmers of Kansas has accomplished a vast amount of good, but beyond this it is impossible to go. Of Professor Snow's laboratory work or the labors of himself and assistants in the fields no criticisms can be made, and there will be occasion to quote from these in future pages of this bulletin.

Sporotrichum globuliferum, or at any rate the fungus which is now passing under that name, was first found by Professor Forbes to infest the chinch bug in Illinois in 1887, and its destructive effects observed in the fields in the autumn of 1888.

Since the last-mentioned date the writer distributed upward of 3,000 packages of this fungus to the farmers of Ohio during the outbreak of the chinch bug in the State in 1895, 1896, and 1897, and knows from personal observation and study that it is under certain favorable conditions a deadly foe of this species, that its use under these conditions is practicable, and that if its application can be made simultaneously with the commencement of the breeding season it will prove effectual. This statement is made for the reason that as late as 1895 Dr. M. C. Cook, in his popular work on entomogenous fungi, " Vegetable Wasps and Plant Worms " (p. 120), states that " no species of this genus is known to have occurred on living matter, as they are saprophytes pure and simple, and then, probably, only as the stroma or conidia of some fungus of higher organization, possibly the Sphæriacei." This statement was made in discussing *S. densum*, but on the following page (121), after dealing with *S. globuliferum*, he appends the following: " The remarks made under the previous species are applicable to this, which is not entitled to rank as a parasite, but rather as an accidental development upon one out of many forms of decaying animal matter."

OTHER INSECTS ATTACKED BY SPOROTRICHUM GLOBULIFERUM.

Spegazzini [a] described the species from Argentina as occurring on the dead bodies of beetles, notably Monocrepidius and *Naupactus xanthographus* Germ. Besides *Parandra brunnea* Fab., Professor Forbes has recorded this fungus on Lachnosterna and a number of other Coleoptera, and also on lepidopterous larvæ, as well as on the young of other insects, while the writer has infected, artificially, *Epicauta pennsylvanica* De G. and witnessed an instance of accidental infection of *Megilla maculata* De G., but failed to infect the harlequin cabbage bug (*Murgantia histrionica* Hahn) even when these were placed among dead and dying chinch bugs in the breeding cages. In both cases these beetles were almost entirely covered by the fungus after having to all appearances died from its effects. With respect to this matter one point is clear, either the determination of this fungus is incorrect or else Doctor Cook has made a very serious misstatement, which ought to be corrected. It is but just to state, however, that Professor Forbes, in his eighth report (p. 23), calls attention to the fact that it is closely allied to Botrytis, and would be placed by some botanists under that genus now.

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[a] Spegazzini, Fungi Argentini, ii, p. 42.

FIRST ARTIFICIAL CULTIVATIONS OF SPOROTRICHUM GLOBULIFERUM.

In April, 1891, Dr. Roland Thaxter succeeded in cultivating *S. globuliferum* artificially on agar-agar, and a month later Professor Forbes made similar cultures on the mixture of corn meal and beef broth, this last being an exceedingly valuable discovery, as it revolutionized our method of distributing the fungus by securing chinch bugs to be kept for a time with those diseased and then sent out to be scattered over the fields—a cumbersome method which was never satisfactory. The writer's own work in Ohio was based on material obtained from Professor Forbes, and the first year he distributed infected chinch bugs, but after that he used the artificial base of beef broth and corn meal, finding the latter far more satisfactory to handle, and, so far as could be determined, equally effective.

RESULTS OF FIELD APPLICATIONS IN OHIO.

In regard to the writer's own experience, it is unnecessary to go into details, except to state that, under the most favorable laboratory conditions, he was able to kill apparently perfectly healthy chinch bugs within three days after bringing them in contact with the Sporotrichum. In the fields, during the season of 1895, though upward of 750 packages of diseased bugs were sent out to farmers, and some astonishing reports of results received therefrom, yet his own observations led him to believe that in many cases these were rather more imaginary than real. Over the areas where local showers occurred during the season of development of the first brood of young the effect was much more satisfactory. But in many cases the request for help came late, and soon after the fungus was applied the bugs scattered out over the fields, disappearing to the eyes of the ordinary farmer, who, of course, attributed all to the effect of the Sporotrichum. In 1896, however, meteorological conditions changed, and at last the writer had the good fortune to secure the very opportunity for which he had been waiting for years. All through April and up to the 10th of May in southern Ohio there was little rain, and even during the remainder of the latter month the light rains hardly sufficed to break the drought, so that there was a perfect breeding season for the chinch bug during the forepart of the breeding period. The result was that over some sections (see fig. 7) there were myriads of young bugs. Then the rains came on, and there were presented the two essential requisites for success with the fungus, viz, chinch bugs and wet weather.

Soon the demands for supplies of Sporotrichum began to pour in, and 1,200 packages were distributed within a few weeks, instructions being given to place the contents of the boxes where the chinch bugs were massed in greatest abundance, giving preference to the lower and damper localities in the fields.

After the distribution had been finished, the sections where the outbreak of chinch bugs had been the most severe and where the larger portion of the Sporotrichum had been distributed were visited. There was certainly no mistaking the effect of the fungus. Going to the place in a field (generally a wheat field) where the fungus had been introduced, the track of the chinch bugs as they moved in any direction was in many cases almost literally paved with the dead bugs more or less enveloped in their winding sheets of white. Along ravines, dead furrows, or other depressions, the ground would be nearly white, the dead diminishing in numbers as the higher grounds were reached, though these were by no means free from corpses. In one instance the bugs had left a field of wheat at harvest, the Sporotrichum having been applied there before the movement began, and entered an adjoining cornfield. The way was marked with white, not only the surface of the ground, but on stirring up the mellow soil of the edge of the cornfield it was found to be literally full of dead chinch bugs to the depth of 2 or 3 inches, the white fungus-covered bodies strongly contrasting with the black color of the rich loam. Not only this, but under the sheaths of the leaves and on the leaves themselves hundreds of dead were to be found on the outer rows of corn, on the grass and weeds, and, indeed, almost everywhere. Millions of chinch bugs were certainly destroyed in this one field.

In other fields, where the number of bugs had been less, the dead were less numerous, and then they were more apt to be scattered over the leaves of the corn, as in such cases a diseased bug seems to be animated with a desire to crawl upward on any object which presents itself, just as a larva of the clover-leaf weevil, *Phytonomus punctatus* Fab., when attacked by *Entomophthora sphærosperma* (Fres.) will climb to the tip of a vertical blade of grass and coil itself around it, and, holding it in the grasp of death, remain in that position so strongly attached that the winds and rains fail to dislodge it until it has become disintegrated. In other localities, where no Sporotrichum had been distributed, the ravages had certainly been greater and the writer failed to find any indication of the presence of the fungus. So far as his observation extended, unless there were a sufficient number of chinch bugs massed to become injurious, the fungus had but little effect upon them. In other words, the massing appeared to be an essential requisite. Whether this was sufficient of itself, or whether the effect of massing was to reduce the vitality of the individual bug, and thus render it more susceptible to the spores of the fungus, it is impossible for the writer to decide; but he has long suspected that the latter was the true solution of the problem. We know that most domestic animals or fowls thrive best and are the most vigorous when kept in small flocks, while among humans the maximum of health and minimum of disease is obtained where the individuals are scattered over a moderate area per capita and the atmosphere is dry and pure; low, damp, and ill-ventilated quarters, when overcrowded, being especially fatal, particularly to the young. The individual in perfect health and vigor may in one sense be said to be above and out of reach of disease, and before the two can be brought together there must be some interacting element that will bring the individual down to a point where he can be reached by the disease; that is, the disease can rise only to a certain plane and the victim needs to be first attacked by some element not necessarily fatal in itself, but sufficiently depressing to bring the individual down to where he can be grasped by the disease.

METEOROLOGICAL INFLUENCES FAVORING DEVELOPMENT OF FUNGOUS ENEMIES OF THE CHINCH BUG.

When human beings are overcrowded and some disease is introduced among them, everyone knows the effect of a low, damp locality under a high temperature and with both air and water more or less stagnant. Even the once healthy and vigorous are more or less reduced and enervated by their environment, and thus brought within the influence of the deadly disease. Again, if an individual is stricken and forsakes his miasmatic surroundings for those more salubrious, the disease may still overcome him, but seldom spreads to others, except such as come in actual contact with either himself or his belongings, while if not too much reduced before changing his habitation the chances are much more favorable for his recovery.

It seems to the writer that in this matter of metorological conditions and their relation to the effect of entomogenous fungi on the chinch bug we are really dealing with the same problem in a different field. The young chinch bug which has not yet come into possession of its full measure of strength, and the spent females, which have lost theirs, fall easiest as the prey to these fungi, while the fully developed bugs, endowed with health and vigor, appear to be to some extent immune to the attacks of these enemies, and if not massed in large bodies they seem still more likely to escape destruction. In the timothy meadows of northeastern Ohio an occasional dead adult has been found in late autumn, but the fungus had certainly not claimed many victims, though both the long and the short winged forms were present in considerable abundance, clustered about the roots of grass. With Forbes the writer believes that after becoming fully matured the chinch bug is, largely at least, beyond the reach of Sporotrichum. What is the element that serves to enervate and reduce the older larvæ and pupæ, as well as many recently developed adults among them? Is there nothing that, not of itself fatal, so acts upon the system of the bugs that they are brought into a condition of susceptibility—a sort of "go-between," so to speak, but which demands atmospheric moisture before it will rise to an aggressive state?

A BACTERIAL ENEMY OF THE CHINCH BUG.

Forbes finds that the bacterium *Bacillus insectorum* Burrill is normal to the chinch bug and occurs always in the intestinal cœca, and the writer has often wondered if this were not the very reducing element. In a paper contributed to the "American Practitioner," September, 1891, he describes the effect of this bacteria on the cœca as completely destroying the secreting epithelium, the cells of which break down and disappear, leaving the delicate tubes filled with a vast mass of microbes with some small intermixture of droplets of fat and a little nondescript *débris*, the result of çellular decomposition. Now, it certainly seems to the writer that we may here have the very enervating element necessary and which, in order to become sufficiently aggressive to perform its functions perfectly, requires the very conditions afforded by frequent showers, without which it is comparatively helpless. We know very well that human beings are far more susceptible to disease when weakened by fatigue, dissipation, or other forms of exhaustion, and under such conditions succumb to disease when they would otherwise enjoy immunity therefrom. We will not, however, follow this further, but submit it as a problem well worthy of careful consideration and study. In his own experiments with *Sporotrichum globuliferum* the writer has found that under the most favorable conditions the fungus will attack even the youngest larvæ, while Forbes states that it will also attack the eggs, but in the fields it seemed generally most prevalent among the more advanced larvæ, pupæ, and newly developed adults, though much depends upon meteorological conditions and the abundance of chinch bugs, as well as the time during the breeding season when the fungus is doing its work. That is to say, there is a time at the beginning of the breeding season when there are only adults and young larvæ; later there will be larvæ of various ages, and, toward the last, few if any of these, but all will be either pupæ or adults. For some reason it seemed more difficult to get the Sporotrichum to work satisfactorily when the chinch bugs were beginning to breed than later on, the last of June and the early part of July. These facts are mentioned here to show that, judging by their effects, these fungi hold a secondary place.

THE PRACTICAL UTILITY OF FUNGOUS AND BACTERIAL ENEMIES IN FIGHTING THE CHINCH BUG.

Regarding the practicability of utilizing these entomogenous fungi in agriculture, there seems no reason to revise a statement made ten years ago, viz, that this can be done only in cases of excessive abundance and during wet weather, the basis for infection being provided by some central propagating station from which farmers can receive promptly an abundant supply. The writer believes that for himself he could manage to get considerable benefit from their use in destroying chinch bugs, provided he were located within the area of the frequent occurrence. This could be done only by watching the seasons carefully, and in case there should occur two years in succession wherein the breeding periods were covered by drought, then every preventive measure known should be adopted, notably the burning of leaves, dead grass, and other rubbish during winter or early spring, followed up by sowing small plats of early millet, Hungarian grass, or, better yet perhaps, spring wheat, in low damp places in the fields, with a view of attracting the females or in fact massing the bugs, and then freely applying the fungi in their midst. Whether the average farmer, with his somewhat crude ideas of entomology, can do this successfully or not is very uncertain. It is almost impossible to determine even a few weeks in advance whether a season is to be favorable or unfavorable to the development of the chinch bug, which would of itself cause occasional false alarm, and the precautionary measures rendered entirely unnecessary by a few timely and drenching rains just at the critical time. Before we can expect to be eminently successful in this matter, not only the farmer but also the entomologist and meteorologist have much to learn.

THE BOBWHITE OR QUAIL.

Chinch bugs have few important enemies among the birds of the northern United States. To what extent the coast birds feed upon them it is impossible to say, but inland the common quail or bobwhite (*Colinus virginianus*) is the only species that can be said to devour any considerable number. As this is one of our most highly prized game birds, it is slaughtered annually in tremendous numbers.

The following list will show the degree of protection offered the quail by legislative enactment in the States where the chinch bug is the most destructive. The close season for quail in the several States, during which killing is prohibited by law, is as follows:[a]

Maine, all the year.

New York, December 1 to November 1, except in some counties where it is from December 1 to October 16. In Rensselaer County it is from December 1 to October 1 and in Richmond County all the year until 1908.

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[a] Farmers' Bulletin No. 265, pp. 13–25, 1906.

Pennsylvania, December 1 to November 1.
Ohio, December 5 to November 15.
Indiana, January 1 to November 10.
Illinois, December 20 to November 10.
Minnesota, December 1 to October 1.
Iowa, December 15 to November 1.
Missouri, January 1 to November 1.
Nebraska, December 1 to November 15.
Kansas, December 15 to November 15, with some exceptions where the close season extends to March 11, 1908.[a]
Oklahoma, February 1 to October 15.
Texas, February 1 to November 1.

The breeding season from latitude 38° northward to Canada begins in May, and continues through July and occasionally into September or even October. A young bird just from the nest was taken in Wayne County, Ohio, September 5, 1887.[b] There are probably two, and southward three, broods each season, and, while rather prolific, the quails are kept well reduced in numbers, at times to the verge of extermination over considerable sections of country. They are hunted incessantly and slaughtered without consideration, except for gain. Some also are killed by flying against electric wires, while entire coveys are sometimes smothered or frozen under the snow. As a result, the helpfulness of the quail against chinch bugs is greatly diminished.

OTHER BIRD ENEMIES OF THE CHINCH BUG.

Among the other bird enemies of the chinch bug are the prairie chicken, redwing blackbird, catbird, brown thrush, meadowlark, house wren, tree swallow, and horned lark, but there is little doubt that in seasons when the chinch bug is excessively abundant the comparatively few eaten by all of these birds is insufficient to reduce the numbers of the pest to any extent.

THE FROG.

Dr. Cyrus Thomas quotes Professor Ross and others as stating that the common frog is an enemy of the chinch bug. While this is probably true, it is nevertheless well known that comparatively few frogs frequent grain fields as a rule, and thus the benefit derived from their attacks is of too little importance to merit further notice.

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[a] In Rawlins County, under restrictions, November 1 to January 1.

[b] A preliminary List of the Birds of Wayne County, Ohio, by Harry C. Oberholser. Bul. Ohio Agric. Exp. Sta., Tech. Ser., Vol. I, No. 4, p. 270.

INVERTEBRATE ENEMIES OF THE CHINCH BUG.

Of the invertebrate enemies the same may be said as of the frog. The writer has occasionally found a chinch bug containing a species of Mermis, "hair snake." Also occasionally ants may be seen dragging these bugs away, while lady-beetles have sometimes been found to devour them, as recorded by Walsh and Forbes. Perhaps the worst insect enemies of the chinch bug are to be found among its comparatively near relatives, the insidious flower bug, *Triphleps insidiosus* Say (*Anthocoris pseudo-chinche* of Fitch's Second Report) (fig. 15), and *Milyas cinctus* Fab. (fig. 16), the latter being reported by Doctor Thomas as the most efficient of the insect enemies of this pest, while Doctor Riley found that the former also attacked it. Professor Forbes ascertained by examinations of the contents of the stomach of a ground beetle, *Agonoderus pallipes* Fab., that one-fifth of the total food of this species was composed of chinch bugs. Doctors Shimer and Walsh both claim that lace-wing flies (*Chrysopa*) destroy chinch bugs, and they are doubtless correct. The writer has also very often found dead chinch bugs entangled in spider webs, though whether killed for food or by accident it has been impossible to determine. It will be seen, however, that the combined influence of all of the natural enemies of the chinch bug, parasitic fungi excepted, is far too weak to offer any material protection to the agriculturist against this pernicious enemy of his crops, with nothing to promise an improved condition of affairs in this direction in the future. There may sometimes appear hymenopterous parasites of the eggs, but we have as yet no proof of the existence of such in this country, and only suspect the possibility of such a phenomenon because other allied species have similar enemies, which destroy their eggs. In short, the immunity of the chinch bug from attacks of other organisms is so striking that it has attracted the attention of all entomologists who have made a study of the species, and all accept this as indicating that it is an exotic, not originally belonging to our insect fauna.

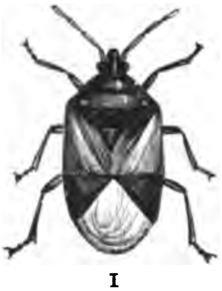

FIG. 15.—*Triphleps insidiosus* Fab. (From Riley.)

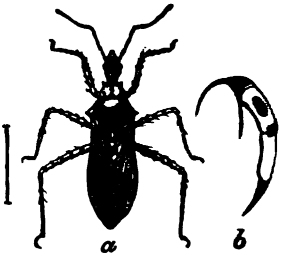

FIG. 16.—*Milyas cinctus* Fab. (From Riley.)

REMEDIAL AND PREVENTIVE MEASURES.

The list will include all remedial and preventive measures that have been found to possess the merit of reasonable efficiency and practicability. These may not all prove applicable in all localities or under every variety of circumstance, and the farmer will often have to fit his protective measure to meet weather conditions, location of field and its surroundings, as well as the thousand and one other variations of a similar nature.

DESTRUCTION OF CHINCH BUGS WHILE IN HIBERNATION.

The first effort that may be made with a view to warding off an attack of chinch bugs is to destroy them in their winter quarters. This can be accomplished by burning all dried grass, leaves, or other rubbish during winter or early spring. Forbes (First Report, p. 37) and Marlatt (Insect Life, VII, p. 232) have cast some doubt upon the statements to the effect that the chinch bug hibernates to any great extent among dried grass, leaves, and rubbish, but the evidence is so overwhelmingly in favor of the assertions of nearly every entomologist who has studied the insect in its hibernation to the effect that it does select such places in which to pass the winter that there is hardly any use of raising the question at all. A good illustration of the fact that large numbers of chinch bugs may be in hiding in such places and escape detection is shown by the fact that a quantity of dried leaves from about a vineyard located on a narrow neck of land about a quarter of a mile from the Bay of Sandusky on the one side and about 1½ miles from the shore of Lake Erie on the opposite side were collected late in April and brought to our insectary and placed in a breeding cage. At the time of collecting the leaves only an occasional chinch bug was to be observed, but under the warm atmosphere of the insectary they began to stir themselves, and soon demonstrated that there had been a large number ensconced unseen among the dried and curled dead grape leaves. So it is with the matted grass along roadsides and fences, especially the Virginia worm rail-fence.

While it is not possible to find the hibernated chinch bugs by searching, yet if pieces of boards are laid down on the grass in early spring the bugs will collect on the under side and may be found there, or they may be discovered by the method of collecting known to entomologists as sifting. The burning of all such grass will destroy thousands of bugs in their winter quarters; but sometimes the matted bluegrass remains green in winter, or the weather is not sufficiently dry to enable the farmer to burn over such places. In such cases a flock of sheep, if given the freedom of the fields during winter and spring, will eat off all living vegetation and trample the ground with their small feet, so that not only is all covering for the bugs removed, but also the bugs are trampled to death. The ease with which the narrow strip of grass land along a post and wire fence can be kept free of matted grass and leaves, as compared with that along a hedge or rail fence, indicates that there may be an entomological factor connected with the modern fence that has been overlooked, giving it, in this respect, an advantage over the more ancient form. Shocks of fodder corn left in the fields over winter certainly afford protection for many chinch bugs, as also will coarse stable manure spread on the fields before the chinch bugs have selected their place of hibernation in the fall. In short, the first protective measure to be carried out is a general cleaning up in winter or early spring either by burning or pasturing or both.

SOWING DECOY PLATS OF ATTRACTIVE GRAINS OR GRASSES IN EARLY SPRING.

Judging from the manner in which the wintered-over adults are attracted to hills of young corn, wheat fields, or plats of panic grass and foxtail, it has always seemed to the writer practicable to take advantage of this habit and sow small patches of millet, Hungarian grass, spring wheat, or even corn, early in the spring and thus bait the adults as they come forth from their places of hibernation. Their instincts will prompt them to seek out the places likely to afford the most desirable food supply for their progeny, and if an artificial supply can be offered them that will be more attractive than that furnished by nature, the bugs will certainly not overlook the fact, but will take advantage of it to congregate and deposit their eggs there, whereupon eggs, young, and adults can, a little later, be summarily dealt with by plowing both bugs and their food under and harrowing and rolling the ground to keep the former from crawling to the surface and escaping. The writer has thoroughly tested this method in a case where the bugs, young and old, had taken possession of a plat of neglected ground overrun with panic grass (*Panicum crus-galli*), which was mown and promptly removed and the ground plowed, harrowed, and rolled before the bugs could escape, thus burying them beneath several inches of soil out of which they were unable to make their way, and as a consequence they were almost totally annihilated, hardly 1 per cent making their escape to an adjoining cornfield.

DIFFICULTY OF REACHING CHINCH BUGS IN MEADOWS.

There is, however, some doubt in regard to the practicability of applying these measures in meadows. Meadow lands can be burned over with perfect safety to either the grass or clover, if done while the ground is frozen, but there is danger of injury if burned over in spring, and it is somewhat doubtful if the hibernating chinch bugs would be killed unless the surface of the ground was heated to a degree that the grass and clover plants would hardly be able to withstand.

Infested areas of meadow land could be plowed, it is true; but the work would have to be done very carefully, else the grass and stubble would be left to protrude above ground along each furrow and constitute so many ladders by which the chinch bugs could easily crawl out and make their escape. Where the ground will admit of subsoiling, or where a "jointer" plow can be used, this latter difficulty can be easily overcome. Usually, however, the chinch bug works too irregularly in a field to permit of plowing under infested areas without disfiguring it too much for practical purposes, especially in the case of meadows, unless it be where the bugs have migrated *en masse* from an adjoining field, when a narrow strip along the border can often be sacrificed to good advantage. In many instances the heroic use of the plow in turning under a few outer rows of corn would have saved as many acres from destruction. In the majority of cases it is the fault of the farmer himself that these measures are not effective, as he will seldom take the trouble to burn the dead leaves, grass, and trash about his premises at the proper time, and when there occurs an invasion of chinch bugs, instead of resorting to heroic and energetic measures to conquer them on a small area he usually hesitates and delays in order to determine whether or not the attack is to be a serious one, and by the time he has decided which it is to be, the matter has gone too far, and the chinch bugs have taken possession of his field. This is especially true in the West, where the bugs breed exclusively in the fields of wheat and remain unobserved until harvest, when they suddenly and without warning precipitate themselves upon the growing corn in adjacent fields. In fighting the chinch bug promptness of action is about as necessary as it is in fighting fire.

WATCHFULNESS NECESSARY DURING PROTRACTED PERIODS OF DROUGHT.

It has always appeared to the writer as though a little watchfulness on the part of farmers during periods of drought might enable them to determine whether or not chinch bugs were present in any considerable numbers in their fields, in time to interpose a strip of millet between the wheat and corn, to be utilized later as previously indicated. Instances have come under observation where, the wheat fields being overgrown with panic grass and meadow foxtail, the bugs transferred their attention to these as soon as the wheat was harvested, and a prompt plowing of the ground would have placed the depredators beyond the possibility of doing any serious injury. If the weather at the time is hot and dry, a mower may be run over the stubble fields or along the borders of them, cutting off grass, weeds, and stubble, as the case may be, leaving them to dry in the hot sun, when, in a few hours, they will burn sufficiently to roast all bugs among them, and, while not destroying every individual, this will reduce their numbers to such an extent that they will be unable to work any serious injury.

In case the weather at the time should, on the contrary, be wet and rainy, so that it is impossible to mow and burn, the prompt distribution of the fungus Sporotrichum will prove of immense value; for in this case the more the bugs are massed over a limited area, the more fatal will be the effects of the fungus, and especially will this prove true if the land is low and inclined to be damp. This statement will also hold good with reference to meadow lands during the breeding season, though later the adults do not appear to succumb to the effects of the fungus nearly as readily, and the writer has found the fungus present in spring among masses of hibernating individuals, with little indication of its contagious nature, only an occasional individual being attacked.

UTILITY OF KEROSENE IN FIGHTING CHINCH BUGS.

In fighting the chinch bug there is at present no more useful substance than kerosene, either in the form of an emulsion or undiluted. From its penetrating nature, prompt action, and fatal effects on the chinch bug, even when applied as an emulsion, it becomes an inexpensive insecticide, while it has the further advantage of being an article of universal use in every farmhouse, and is therefore always at hand for immediate use. The emulsion has the further advantage of being capable of sufficient reduction in strength to prove fatal to insect life and yet not injure the vegetation upon which such may be depredating. Diluted and ready for use, the emulsion is prepared as follows: Dissolve one-half pound of hard soap in 1 gallon of water, preferably rain water, heated to the boiling point over a brisk fire, and pour this suds while still hot into 2 gallons of kerosene. Churn or otherwise agitate this mixture for a few minutes until it becomes of a cream-like consistency and, on cooling, will form a jelly-like mass which adheres to the surface of glass without oiliness. For each gallon of this emulsion use 15 gallons of water, mixing thoroughly. If applied to growing corn it will be best to use the emulsion either during the morning or evening, say before 8 a. m. or after 5 p. m., as at those times it will be less likely to affect the plants than if applied in the heat of the day.

Where an invasion of the chinch bug is in progress from a field of wheat to an adjoining field of corn, as an illustration, the marginal rows of corn can frequently be saved, even after the bugs have massed upon the plants, by spraying or sprinkling them freely with kerosene emulsion, being careful not to get much of it directly into the crown of the plants and using a sufficient quantity so that the emulsion will run down the outside and reach such bugs as are about the base of the plants. This treatment will kill the bugs clustered upon the corn, and in case of those on the way to the field, while it will not keep them out, it will cause a halt in the invasion, and thus give the farmer an opportunity to put other measures in operation, one of which will include the use of kerosene in another manner. If a deep furrow is plowed along the edge of the field, running the land-side of the plow toward the field to be protected, the furrow will form a temporary barrier to the incoming hordes.

UTILITY OF DEEPLY PLOWED FURROWS SUPPLEMENTED BY THE USE OF KEROSENE EMULSION.

In dry weather the sides of this furrow can be made so steep and the soil so finely pulverized that when the chinch bugs attempt to crawl up out of the furrow they will continually roll back to the bottom, where they can be sprinkled with either kerosene alone or with the much less expensive emulsion, and killed. In case of showery weather, which prevents the sides of the furrow from remaining loose and dry, the bottom can be cleared out with a shovel, making it more smooth and the sides more perpendicular, thus rendering it so much easier to follow along the bottom than to attempt to climb the sides. If holes are dug across the bottom at distances of, say, 30 or 40 feet, the bugs will fall into them and can be still more easily disposed of by the use of kerosene. That both of these measures are thoroughly practicable the writer has ample personal experience in evidence, and knows that under most conditions that are likely to obtain, prompt and efficient application is all that is necessary. During a few days this work will demand the closest watching and application, but fields of grain can be protected thoroughly and effectually if these measures are faithfully carried out, and the expense of time and money will be found to be less than in almost any other plan that has been up to this time discovered. In his own experience, in no case has a field attacked by a migrating army of chinch bugs come under the writer's observation, but that might have been saved from very serious injury by the prompt use of either of these measures, though under some conditions the farmer might find it advantageous to apply some of the other methods of protection here given.

THE SURFACE AND COAL-TAR METHOD.

The objections made by farmers to the use of most forms of these barriers is that the finest pulverized soil soon becomes incrusted by even the slightest rainfall and the bugs then pass over it without difficulty, while barriers of boards are expensive.

It is feasible to eliminate both by simply smoothing off a path along the margin of an infested field where such a one adjoins the one to be protected. This can be done with a sharp hoe, and as the margins of wheat fields usually become compacted it is but little trouble to thus clear off a path a foot or more in width, smooth as a floor, with the surface almost as hard. In the midst of this path post holes are sunk as in the bottoms of furrows, and a train of coal tar is run between them, being so arranged that it will reach the post hole near the inner side opposite the field from which the bugs are migrating. In this way as the bugs reach the train of coal tar they will follow along until they reach the post hole, while those meeting with the post holes will usually divide and, following around it, join with the flow of bugs moving along the train of coal tar. The result is that they become congested in the acute angle where the coal-tar train is intercepted by the post holes. Those in the apex of this angle can not turn back, and thus are continually pushed into the post holes by those behind. As the bugs, varying from the red larvæ to the almost black pupæ, mass along the line of coal tar they have much the appearance of a reddish-brown stream running into the holes. From these holes there is no escape and here the bugs can be readily killed by sprinkling with kerosene. The slightest train of coal tar is sufficient to obstruct the passage of the bugs, and light rains will not affect its efficiency. In dry weather these trains of coal tar soon become covered over with dust and must be renewed; but in showery weather there is no dust, and if the coal tar is renewed daily or, at most, twice each day it will accomplish its work and nothing further will be needed than to kill the bugs that have collected in the post holes. This measure is inexpensive and can be promptly put into operation if the coal tar is at hand. The writer has been able in this way to effectively protect a field of corn surrounded on two sides by a wheat field literally overrun with chinch bugs at harvest and during a time when light showers were occurring, frequently several times each day.

THE RIDGE AND COAL-TAR METHOD.

Differing quite materially from the preceding are the various combinations of coal tar and ridges of earth, smoothed and packed along the apex, or, instead of the ridge of earth, 6-inch boards, such as are ordinarily used for fencing, placed on edge and the upper edge coated with tar. Forbes has reported excellent results from the application of a line of coal tar put directly upon the bare ground where the surface has been rendered compact by a recent fall of rain. Even in this series of protective measures kerosene can be used to great advantage. In the experiment recorded by Professor Forbes the coal tar was put upon the ground between a wheat field and a cornfield from an ordinary garden sprinkling pot from which the sprinkler had been removed and the orifice of the spout reduced in size with a plug of wood until the tar came out in a stream about the size of the little finger and made a line on the surface of the ground about three-fourths of an inch in width. Post holes were sunk along the line from 10 to 20 feet apart on the side next to the wheat field, thus practically completing the barrier, and the chinch bugs being unable to cross the line of tar accumulated in the post holes in vast numbers, where they were killed; and those bugs that had already entered the cornfield before the barrier was constructed were prevented from spreading farther by tar lines between the rows of corn, the infested corn itself being cleared of bugs by the application of kerosene emulsion. The same writer states[a] that several farmers in Vermilion County, Ill., prepared for the coal-tar line by hitching a team to a heavy plank and running this, weighted down with three or four men, over the ground once or twice until a smooth, hard surface had thus been made to receive the tar. If the barrier was to be made in sod, a furrow was plowed and the bottom of this made smooth by dragging the plank along the bottom. In both cases post holes were sunk along the tar lines, and in these were placed cans or jars into which the bugs fell in myriads and were destroyed.

On one farm of 250 acres a coal-tar line 90 rods in length was renewed once each day and killed about 8 gallons of chinch bugs. In the case of another farmer there were 300 rods of tar lines with post holes, cans, etc., which resulted in destroying about 10 bushels of chinch bugs. A 6-gallon jarful was destroyed in less than half a day at one point on the line. In this last instance the lines of tar were renewed three times a day, but even then less than a barrel of tar was used. Still another farmer, with 120 rods of tar line, used about a third of a barrel of tar and did not lose a hill of corn; he caught chinch bugs by the bushel. In some of the cases cited the tar line was run in a zigzag course, the post holes being situated at the angles, and in others leader tar lines were run obliquely to the main tar line, one end terminating at the traphole, but both of these plans were afterwards regarded as unnecessary, a single straight line being entirely sufficient and less expensive. The numerous cases where these methods were put into execution with entire success and at small expense is the best possible proof of their practical utility. If a farmer is situated near town, where refuse tin cans are dumped in any locality where they can be got out of the way, he can select the larger of these, set them in the post holes and partly fill them with kerosene and water. The water being heavier than the kerosene will sink to the bottom, leaving a stratum of kerosene on the surface.

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[a] Twentieth Report of State Entomologist of Illinois, p. 39, 1898.

The chinch bugs falling into this will be forced down by the weight of those coming after, and thus all will be passed through the kerosene into the water below. This will obviate the necessity of frequently emptying the cans or treating their contents. It may also be stated that where the post holes are quite deep and enlarged at the bottom the bugs falling into them will perish without further attention.

OTHER BARRIER METHODS.

Professor Snow, working in Kansas, followed a somewhat different method and one that, under certain conditions, might be found superior to that used by Professor Forbes, or the furrow and kerosene method applied by the writer in Ohio. This modification consists in throwing up a double furrow, known among farmers as "back furrowing," and thus forming a ridge, the top of which is smoothed and packed with a drag having a concave bottom of the form of the ridge to be made. If the bottom of this drag is covered with zinc, it will be found to keep bright and polished and by this means make a smoother ridge. The substances used were coal tar as it came from the gas works and crude petroleum as taken from the oil wells. The former is the more easily obtained, except in certain localities, and will probably be found the more practical, as it stands on the surface better and is not so readily washed away by rains. Both of these substances are, however, offensive to the bugs, and they will seldom attempt to cross them or even come close enough to touch them, but on approaching will turn and run along the ridge in the evident hope of finding a gap through which they can pass. Post holes were dug on the outside of the line, but close up to it, so that the bugs in passing along beside the tar line would crowd each other into them. Professor Snow suggests that it will be better to construct this barrier several weeks prior to its being needed, as then the tar line has but to be run along the ridge and the post holes dug, when the whole system is complete and the chinch bugs can be thus shut out from the first.[a]

With these barriers of either ridge or furrow and the use of coal tar or crude petroleum, supplemented by kerosene emulsion, a very large percentage of the injury from chinch bugs may be prevented, and, in fact, with a reasonable degree of watchfulness and prompt action, all injury from migrating hordes may be prevented. The use of tarred boards set on edge or slightly reclining might, under some circumstances, take the place of the ridge or furrow, but these cases will be exceptional, and the use of kerosene emulsion will probably be found equally practicable here, as also will the post holes for collecting the chinch bugs. This method is merely cited in order to call attention to its possible use where the others are found impracticable. The plowing of furrows has been in vogue since the first writings of Le Baron and the second report of Doctor Fitch, and may be utilized in other ways than those previously mentioned. A heavy log dragged back and forth in this furrow will pulverize the soil in dry weather, and Forbes has recorded the fact that where this has a temperature of 110° to 116° F. it is fatal to the young bugs that fall into the furrow, even if they are not killed by the log. As 120° is not uncommon in an exposed furrow on a hot summer day, it will be observed that there may be cases where this method will be found very serviceable, and especially is this likely to prove true in a sandy soil with a southern exposure. In sections of the country where irrigation is practiced these furrows may be flooded and in this way rendered still more effective without the expenditure of either time or money to keep them in constant repair. Doctor Riley long ago laid considerable stress on this measure, believing it of much value, especially in the arid regions of the far West. The same writer advised the flooding of infested fields, wherever it could be done, for a day or so occasionally during the month of May. It is hardly probable, however, that this will often be found feasible except in rice fields, where it is sometimes practiced.

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[a] Fifth annual Report of the Director of the Experimental Station of the University of Kansas, for the year 1895 (1896), pp. 45–47.

NECESSITY FOR PREVENTING CHINCH BUGS FROM BECOMING ESTABLISHED IN FIELDS OF WHEAT AND GRASS.

In the foregoing it will be observed that prevention of migration has been the chief end in view either by destroying the chinch bugs in their hibernating quarters, and thus preventing the spring migration to the breeding places, or by various traps and obstructions to prevent them from migrating from such places to others not already infested. The great problem remaining to be solved is to prevent their breeding in wheat fields at all. As has been shown, it is absolutely impossible, with our present inability to forecast the weather months in advance, to be able to foretell whether or not an outbreak of chinch bugs is likely to take place. There may be an abundance of bugs in the fall—enough to cause an outbreak over a wide section of country—and these may winter over in sufficient numbers to cause some injury in spring, yet a few timely, drenching rains will outbalance all of these factors, and our wisest prognostications fail of proving true. It is this very factor of uncertainty that renders unlikely the successful carrying out, over any large area of country, of any protective measures where, as in this case, the benefit to be derived will only be realized nearly a year afterwards, if at all. The average farmer, when smarting under a heavy loss, will often take such long-range precautions as to sow belts of flax, hemp, clover, or buckwheat around his wheat field once; but if the chinch bugs do not appear, and he sees the useless investment of time, labor, and seed, he will be likely to conclude next year to take the risk and do nothing. For the present, then, we have no method whereby we can prevent the chinch bugs from taking up their abode in wheat fields or timothy meadows and raising their enormous families there, except to destroy the adults in their winter quarters.

The writer once tried to destroy the young in a wheat field by spraying with kerosene emulsion the small areas of whitening grain that indicated where the pests were massed in greatest abundance. The result was unsatisfactory, and it is very doubtful if it is possible to apply this measure with any degree of success, and we are forced to the conclusion that, for the present at least, we shall be obliged to rely upon the measures previously given. It therefore becomes of the utmost importance to clean up the roadsides, and along fences and patches of woodland, as well as any other places likely to afford protection for the hibernating chinch bugs. There are of course obstacles in the way of carrying out this plan generally over any large area of country, and especially in sections where the rail fence predominates. But as the country gets older it will be found that it is not chinch bugs alone that seek these places in which to pass the winter, but myriads of the other insect foes of the farmer as well, and that careful attention to the condition of roadsides, lanes, hedgerows, and waste places about the farms, during the season when insects seek out these places wherein to pass the winter, will pay well for the time expended in that direction. It may come about that some phase of the street-cleaning reform may invade the country, and it is certain that if such were to occur it would, in time, save the country enough to go far toward reducing the expense of securing good roads. In fact, the term "good roads" ought to include the proper care of the roadsides, as well as the grading and macadamizing of the roadbed itself.

There are at present so-called weed laws in many States, and, though more or less of a dead letter in most cases, these laws are steps in the proper direction. The time when insect pests will be looked upon in the eye of the law as so many public nuisances, and the harboring of them a corresponding crime, may be a long way off, but as it gradually draws nearer to us we shall come to learn that, after all, it is the rational view to take and will go far toward solving not only the chinch bug problem, but many others of a similar nature. So far as the chinch bug is concerned, when we burn over the waste lands and accumulated rubbish about our farms in autumn or winter, we are simply applying the same check that the dusky savage did when he lighted the prairie fires, though unwittingly and for an entirely different purpose. In the timothy meadows of the northeastern portion of the country, where, for lack of wings fitted for locomotion, the chinch bug does not so largely migrate to the waste lands in autumn, the problem is somewhat different, and it will require some careful experiments to determine the exact effects of burning over the meadow lands in winter, both on the hibernating chinch bugs and on the grass roots. There can be little doubt, however, that a rapid rotation of crops, so as not to allow the short-winged form to become thoroughly established in a meadow, and the burning over of waste places, thus destroying such rubbish and débris as will serve to offer hibernating places for the long-winged form, will go far toward settling the chinch bug problem in grass lands.

As previously stated, the chief drawback in putting preventive measures in force is in the difficulty of foretelling an invasion. In northeastern Ohio in 1897 hundreds of acres of timothy meadow were destroyed after the hay crop had been removed, but so late that the farmers did not suspect the true condition of their meadows until the spring of 1898, when the young grass failed to put forth and an examination revealed the fact that the roots had been killed, the abundance of chinch bugs pointing unerringly to the cause of the trouble, though in many cases a heavy crop of hay had been removed the previous year where now the ground was entirely bare. While in the case just cited a previous knowledge of the presence of chinch bugs in these meadows might not have enabled the owners to have saved them in the fall of 1897, yet the fall plowing of the land, possibly early enough to have sown the ground to fall wheat, would have buried the majority of the bugs so deeply in the soil as to have killed vast numbers of them and thus prevented their migrating to other lands in the spring of 1898. A rotation of crops that would have included grass for not to exceed two successive years, followed by wheat, would have amounted to precisely the same remedial measure as the one suggested.

A case in northeastern Ohio has come to the writer's notice where an infested timothy meadow was plowed late in the fall of 1897. Late in April of 1898 this ground was cultivated, rolled, and harrowed several times and most carefully and completely prepared for corn, which was planted, but with the result that a portion of the field was attacked and destroyed by chinch bugs, largely of the brachypterous or short-winged form. An examination about June 10 revealed the bugs in considerable numbers about the still remaining plants, but scattered over the field were more or less numerous clumps of timothy, in some cases apparently having been killed by the chinch bugs, while in others these were literally swarming about the dying but still green clumps of grass, thus showing that the former had either not been buried by the plowing and cultivation of the ground, or else the grass had not been thoroughly covered, and thus ladders had been left whereby they were enabled to climb to the surface.

SUMMARY OF REMEDIAL AND PREVENTIVE MEASURES.

In summing up the matter of remedial and preventive measures for the control of the chinch bug, it may be stated that the insects can be destroyed in their places of hibernation by the use of fire. They can, under favorable meteorological conditions, be destroyed in the fields, if present in sufficient abundance during the breeding season, by the use of the fungus *Sporotrichum globuliferum*, if promptly and carefully applied. They can be destroyed while in the act of migrating from one field to another by tarred barriers or deep furrows supplemented by post holes, and by being buried under the surface of the ground with the plow and harrow; or the latter method can be applied after the bugs have been massed upon plats of some kind of vegetation for which the bugs are known to have a special fondness, which decoys should be so arranged as to either attract the females and induce them to oviposit therein, or they should be arranged with the idea of intercepting an invasion from wheat fields into cornfields. When these decoys have been turned under with a plow and the surface immediately smoothed and packed by harrow and roller, the bugs will be destroyed. While in the cornfields they can be destroyed on the plants by the application of kerosene emulsion. Without vigilance and prompt action, however, only indifferent results are to be expected from any of these measures.

PROBABLE ORIGIN AND DIFFUSION OF THE CHINCH BUG.

For the farmer engaged in attempts to check the ravages of the insect in his fields the question of origin, or how it came to reach him, will at the time have little interest for him. It will suffice that it is present in overwhelming numbers, and what he will most desire will be to learn how to rid his premises of its most unwelcome presence in the most summary manner possible.

If, however, the farmer happens to be a thoughtful and observing man he will sometimes wonder how it is that, except in Virginia and the Carolinas, a person need not be very aged in order to remember a time when the chinch bug was an unknown factor in his profession, with a possible value far too small to merit consideration. If he happens to reside in northeastern Ohio or in some portions of New York, and has spent some time in Illinois, Iowa, Kansas, or Minnesota, he will probably marvel at the striking difference in appearance between many of the chinch bugs of his own locality and those found in any of the last-mentioned States, and will probably be able to satisfy himself of their identity only by the similarity of their vile odor. Again, he will probably be equally at a loss to understand why it is that his own timothy meadows are overrun by these pestiferous insects and destroyed, while in other localities, perhaps less than 100 miles away, similar meadows are left untouched, the injury there being confined to the wheat and corn fields.

If wondering leads to questioning, as it often does among the constantly increasing number of educated and up-to-date farmers, it will not satisfy him to receive an evasive or obscure reply to his query as to why such differences exist, for if he can not get a clear explanation he will want ideas, theories, or possibilities. He wants the best explanation possible to give until some one finds out a better one, realizing that had mankind been perfectly satisfied with the knowledge that a stroke of lightning would split a tree or destroy human life, and had stubbornly refused to listen to possibilities or to anything but facts, we would not now be able to understand and utilize electricity in the many ways that we do at the present time. Such men understand perfectly that the solution of most problems in natural science must of necessity commence with theories which must be patiently tested and adopted or rejected as the results demand, while the scientific man knows that the solution of one problem often opens up the way for the solution of another, the last not infrequently having an entirely different application from the first.

The science of applied entomology is growing rapidly and becoming both broader and deeper, and it is not enough simply to tell the husbandman what an insect is and how to kill it. He must have something along with that information to set his own mind to thinking, to work out problems or improve upon the solutions already given him, otherwise it is much like giving money to a professional beggar. If we can not give facts based upon demonstrations, then give the best explanation possible, even though it be a theory which is only expected to stand until some one does better. It is for the thoughtful, progressive farmer, as well as the student of geographical distribution, that this possible solution of the problem of the chinch bug has been prepared, and while the full practical value of the ideas advanced has yet to be demonstrated, this of itself can not be urged as sufficient grounds for not sending it forth for study and consideration.

Thanks to the careful observations of Professor Sajö, on the European species of chinch bug, *Blissus doriæ*, it is now for the first time possible to compare the habits of this species with our own.

INDICATIONS OF A PROBABLE DISTANT ORIGIN AND LATER DIFFUSION.

In the United States our chinch bug, *Blissus leucopterus*, has a number of peculiar characteristics, which, while having an economic interest, also point to a probable previous condition differing somewhat from the present, and not in all cases tending toward its present numerical strength. On the other hand, we find that it is now following some probably ancient habits which do not appear to be of any special benefit, but rather the reverse.

In the first place, over its area of greatest destruction, it appears to prefer level tracts of country where the damp conditions consequent upon frequent rainfalls remain the longest, and in the second place, the period of spring oviposition is for the most part included within that during which the spring rains of the United States usually occur—that is to say, throughout the great grain belt, east of the Rocky Mountains, April and May are not normally months of severe drought, and it is during these two months that the larger portion of the eggs are deposited. As in the reverse of this, however, the period of fall oviposition, August and September, is far more likely to be favored by a lack of precipitation. These conditions do not always obtain, and it is because of the fluctuations that the insect is able to reach its maximum in point of numbers.

Another factor which plays quite an important part in reducing the number of adults maturing during unfavorable seasons may be found in the almost universally gregarious habits of the young, thereby rendering the ravages of fungous diseases the more universal and fatal. In all of these peculiar characteristics as well as in some anatomical features, it would seem as if we had a series of guide posts, so to speak, which indicate more or less clearly the ancient home of the species, and at least throw some light on its origin and diffusion.

UNIQUE APPEARANCE AND GREGARIOUS HABIT.

Mr. E. A. Schwarz [a] some time ago called attention to "the unique appearance of the full-grown chinch bug, with its white wings and chalky-white pubescence," which, he declared, "forcibly indicates that the insect is either a psammophilous or a maritime species," and expressed the opinion that its geographical distribution fully bears out the theory that it belongs to the latter class. The same author states that the species has the habit of clustering about the roots of tufts of grass along the Atlantic coast, from Florida to Atlantic City, N. J., and Mr. W. H. Harrington [b] observed it to have the same habit along the seashore at Sydney, Cape Breton, in 1884. The late Dr.

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[a] Insect Life, Vol. VII, p. 420.

[b] Can. Ent., Vol. XXVI, p. 218.

J. C. Neal, while at Stillwater, Okla., wrote me that he had observed the species to have the same habit in that Territory, miles from any human habitation. Dr. Asa Fitch[a] found them swarming amidst extensive prairies in Illinois, in 1854, while more recently Mr. C. L. Marlatt has witnessed the same phenomenon in Kansas.[b] In short, this gregarious habit seems to be most tenaciously adhered to wherever these insects are found in any numbers. When migrating from one field to another, after crossing a roadway or plowed field they will at once flock together on a few plants along the margin of the, to them, new field instead of scattering about, two or three to a plant. It may also be added that Mr. Koebele found the species in large numbers along the seashore not far from San Francisco, Cal., in the first, second, and third stages of development, on a species of grass growing along the coast.

It has not, so far as is known to the writer, been observed in similar places along the shores of the Great Lakes, though search has been made for it there, but it occurs in destructive abundance in timothy meadows inland in northern and northeastern Ohio 25 to 75 miles distant, most generally clustering about the roots of grass—which, by the way, is about the only vegetation attacked—as the species is described as doing along the seacoasts. It may also be stated that it seems to hibernate there precisely as observed by Mr. Marlatt in Kansas; Doctor Neal in Oklahoma; Mr. Schwarz in Virgina in the vicinity of Fortress Monroe, and as the earlier observations of Doctor Fitch in Illinois would imply. Thus we find this habit of clustering upon the plants attacked to be a constant one, and where the natural grass vegetation has not been displaced by farm crops, thus leaving the ground more or less bare during winter, the chinch bugs continue to hibernate there. With these two characteristic habits generally followed over the great area inhabited by the species in North America, we may add a third possible factor in the problem of origin and diffusion of the species which, though an anatomical dimorphism, may be discussed as likely to throw considerable light upon the probable ancient habitat of the insect.

OCCURRENCE OF THE LONG AND SHORT WINGED FORMS AND THEIR DISTRIBUTION.

The occurrence of both the long and short winged forms, intermixed along our seacoasts and in the northeastern section of the country, but not elsewhere, shows very plainly that this dimorphism is not due to the temperature of any particular locality, but must be regarded as having been brought about by disuse of the wings for a considerable period of time, thus indicating a seashore habit on the one side, while the total lack of the short-winged form elsewhere indicated otherwise.

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[a] Second Report, Insects of New York, p. 283.

[b] Insect Life, Vol. VII, pp. 232–234.

In a paper presented before the Entomological Society of Washington,[a] "On the insects found on *Uniola paniculata* in southeastern Florida," by Mr. E. A. Schwarz, the author stated that *Blissus leucopterus* occurred in large numbers on the upper part of the plant. the imagos and larger young among the ears and the smaller individuals between the upper blades. Mr. Schwarz attributes this habit to the tough woody nature of the storm-beaten plant nearer the ground, thereby driving the insects to the more tender though more exposed portion of the plant. In connection with this statement the writer tells us that the insect occurs in that southern latitude only in the short-winged form, and that in the examination of thousands of specimens from that region he had never found a single long-winged specimen. Under date of May 4, 1896, Mr. W. H. Harrington wrote of this species as follows: "In September, 1890, I found it at Aulac, almost on the border between New Brunswick and Nova Scotia. It seemed not uncommon and occurred under stones, about the roots of grass, in a pasture adjoining the marsh where I found *Diabrotica longicornis*, the pasture being on the upland skirting the marsh. Both the long and short winged condition occurred, as in Cape Breton."[b] Dr. A. S. Packard communicated to Dr. J. A. Lintner the following extract from his diary: "June 17, 1871, at Salem, Mass., chinch bugs with wing covers extending over the basal third of the abdomen, seen in copula, end to end.[c] In the serious outbreak of this insect in the timothy meadows of northern New York, in 1882 and 1883, about 20 per cent of the bugs were of this short-winged form."[d]

Although Dr. Asa Fitch, as early as 1855, refers to this form along with nine others, he does not give the source from which he obtained specimens, but just previous to this he says (p. 287) that he had met with but three specimens from his own State, and these were found on willow in the spring of 1847.[e] Had any of these been of the short-winged form he would have been very likely to have mentioned the fact. Mr. E. P. Van Duzee[f] states that he had known of the occurrence of the species in western New York as early as 1874, and had also found it at Ridgeway and Muskoka, Ontario. Ordinarily the short-winged form predominates, but in hot, dry summers the chinch bugs mostly acquire fully developed wings. He had never found the species in grain fields of any sort, but always in grass lands, generally in timothy or clover, but sometimes in wild grasses. Of eleven specimens collected from under the bark of an old log by Mr. J. Pettit, of Grimsby, Ontario, in 1866, and sent to Mr. B. D. Walsh for determination, all were of the short-winged form.[a] It was these specimens that doubtless led Doctor Riley[b] to call attention to the fact that in Europe there are many genera of half-winged bugs which occur in two distinct or "dimorphous" forms with no intermediate grades between the two, viz, a short-winged or sometimes a completely wingless type and a long-winged type. Frequently the two occur together and copulate promiscuously, while sometimes the long-winged type occurs in particular seasons, especially in very hot seasons, while more rarely the short-winged type occurs in a different locality from the long-winged type, and usually in that case in a more northern locality. In northeastern Ohio the species occurs during some years in great abundance and very largely at least on timothy. Here the short-winged form is very largely in the majority, and in the spring of 1897, of 1,900 specimens collected indiscriminately, only about 400 were of the long-winged type.

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[a] Proc. Ent. Soc. Washington, Vol. I, p. 104. Read Nov. 3, 1887.

[b] Canadian Entomologist, Vol. XIV, p. 218.

[c] Lintner's Second Report, State Entomologist of New York, p. 164.

[d] Second Report, State Entomologist of New York, p. 156.

[e] Second Report on Noxious Insects of New York, p. 291.

[f] Canadian Entomologist, Vol. XVII, pp. 209–210, 1886.

In northern Indiana, where the insect occurs but rarely, this short-winged type does not predominate; but aside from these two localities, with an acquaintance with this species running over forty years, chiefly in Indiana and Illinois, the writer has never met with the short-winged type among millions of adults. If this short-winged type occurs elsewhere to the westward, except along the Pacific coast, where both forms have been collected by Koebele and others, it has not been found by entomologists, even to the northward as far as Minnesota, Winnipeg, and Manitoba, while to the eastward of this Mr. Van Duzee collected the brachypterous form on Muskoka River, Ontario, near the lake of that name.[c] On comparing specimens from New York with a large series from Kansas, the former were found to be quite uniformly more robust, with longer hairs on the pronotum.[d]

It would seem that here we have evidence of two distinct tides of migration, the one sweeping north and eastward, while the other has mainly been to the north and westward, meeting the former in northeastern Ohio and northern Indiana, and possibly somewhere farther to the north in British America. The two, besides differing in the length of the wings, are sufficiently unlike in appearance to attract the attention of students of Hemiptera.

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[a] Practical Entomologist, Vol. II, p. 23.

[b] Second Report on the Insects of Missouri, p. 22, 1870.

[c] Can. Ent., Vol. XXI, p. 3, 1889.

[d] Loc. cit., Vol. XVIII, p. 209.

RELATION OF THE INLAND AND SEACOAST SHORT-WINGED FORMS.

It is possible that the short-winged form of chinch bug found in Ohio is precisely the same form as that found along the seacoasts, but it seems to the writer that the inland form originating from this maritime short-winged element, instead of acquiring wings of normal length as it drifted away from the coast, has really moved in the other direction, and the wings have become still further aborted.

It will be observed by the illustrations given of both the inland and maritime short-winged forms (see figs. 3 and 4) that in some of the former the wings have become so aborted as to become almost invisible, while in the latter, though the wings are very much shortened, they are nevertheless very clearly to be observed. It would seem, then, that we might reasonably presume that the species was originally long-winged, but, living along the seashore, the winged individuals have either flown each year inland or else been blown into the sea to such an extent that a short-winged form has thus been evolved which was unable to migrate and not easily blown into the sea. In pushing inland while the country was still inhabited by the aboriginees another source of destruction would confront these insects in the annual recurrence of fires whereby vast areas of country were burned over in autumn, winter, or early spring, and these must have destroyed very many of the hibernating insects, while such individuals as migrated to sections not so burned over would escape destruction.

PROBABLE COURSE OF DIFFUSION.

Let us suppose that the species originally worked its way northward from South America, or even Panama, along the lowlands between the more mountainous interior and the Gulf of Mexico until it reached Texas with its vast areas of level country extending not only across the State itself, but northward into British America, and, generally speaking, with the exception of the Ozark Mountains in Missouri and Arkansas, eastward to the Appalachian system extending from Cape Gaspé, Quebec, Canada, to northern Alabama. This area is more or less covered with a grass flora that affords ample food for these insects, and it would seem that there was here offered every incentive to migration broadly to the northward and eastward, and at the same time there would be the Gulf coast along which those individuals which either could not or did not migrate inland could make their way as had their progenitors along the coast in Mexico. (See fig. 17.)

Now, it would appear as though the short-winged individuals, if there were any such, would remain along the coast, while the long-winged individuals would, at least more or less of them, migrate inland, and at least some of these, but far more of those unable to fly,

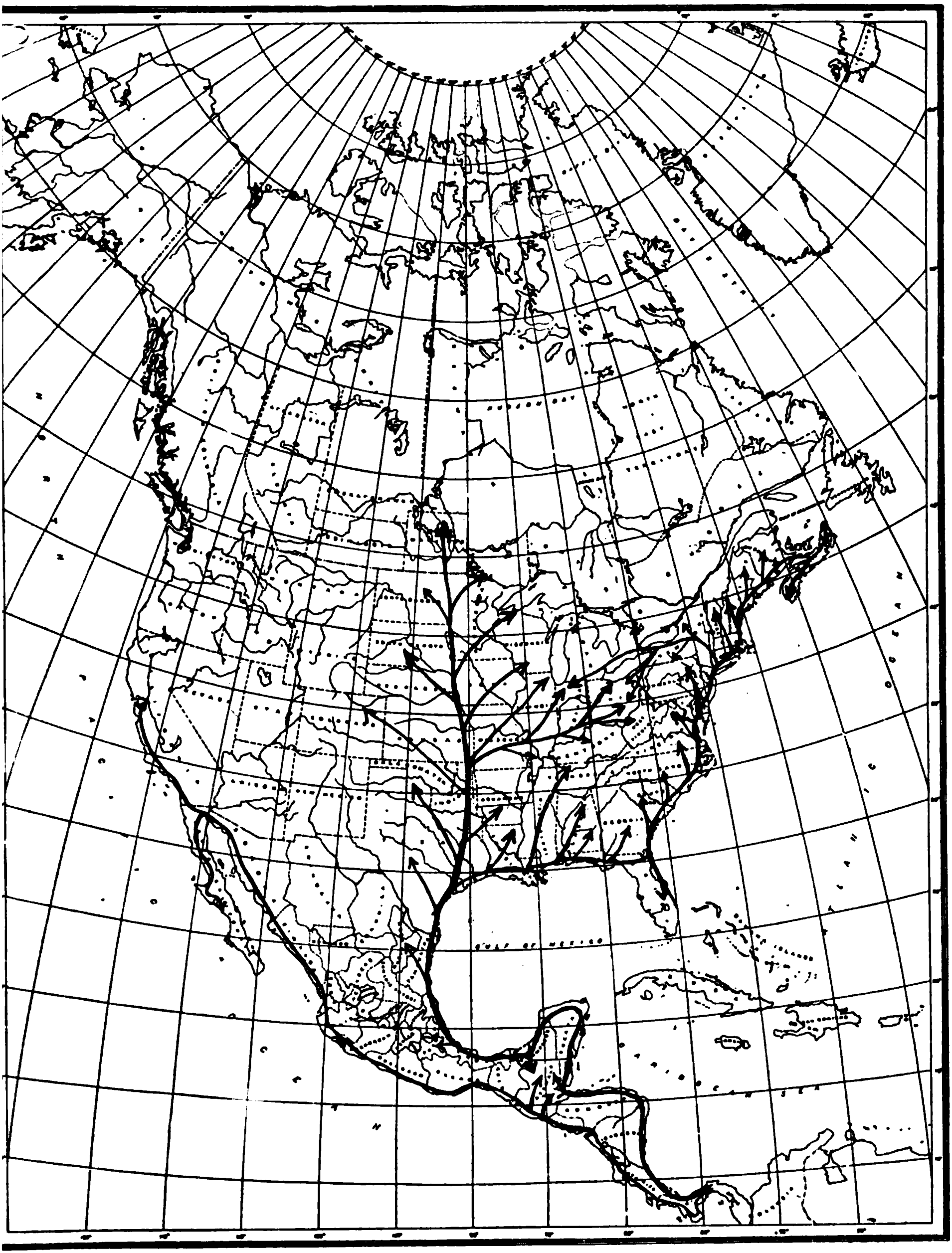

FIG. 17.—Map showing probable course of diffusion of chinch bug over North America. (Author's illustration.)

would be annually destroyed by the prairie fires, thus eliminating whatever tendency there might be to perpetuate the brachypterous forms, and develop a fully winged more or less nomadic race which, as it slowly advanced inland, lost all vestige of its brachypterous ancestry, if such had existed.[a]

On the other hand, we might expect the shore-inhabiting individuals to continue in their progress along the coast, the winged individuals continually migrating inland, leaving a mixture of the two forms to push forward to the east coast of Florida—where as late as 1906 it attacked grass on lawns about Palm Beach—and northward along the Atlantic to Cape Breton. As soon as this migration had passed the southern terminus of the Allegheny Mountains the inland spread would, very largely at least, be restricted to the area lying between the eastern slope of these mountains and the coast, thus leaving the whole area to the west to be occupied by the northward tide of migration instead of that from the east. East of the Mississippi River and south of the Ohio River the country is more heavily timbered and the prairies are lacking, so that forest fires would here take the place of prairie fires; but in the Southern States the woods are composed more largely of pine, and Doctor Lugger, in Minnesota, found that the chinch bug did not invade the region on which only pine and other Coniferæ grew, but that the more southern counties of his State, which are more or less wooded with deciduous trees, were invaded. He also called attention to the fact that before the country was settled by the whites these timbered lands were burned over frequently, probably annually, but now the wooded areas are confined to small tracts interspersed among the farms, and as these are not annually burned over they afford suitable shelters for the chinch bug during winter, and the grain fields of the farmer afford ample food during the summer, while on the prairies which are burned over such is not the case.[b]

Along the eastern coast the chinch bug has never been especially destructive to the wheat crop north of North Carolina, where, according to Doctor Fitch,[c] the earliest depredations occurred in 1783, while Webster[d] states that it threatened total destruction to the grain in 1785; but since that time the ravages have not been nearly as severe as farther west in the Mississippi River Valley. In 1899, 1900, 1901, and 1902 this maritime form destroyed the timothy in the vicinity of Reidsville, N. C. This is on the southern border of timothy culture along the Atlantic coast, and some years ago an attempt was made to grow timothy in that section. The grass did very well until the above-mentioned attack occurred, and by 1905 there was but little remaining.[a] Strangely, too, nowhere along the Atlantic coast do we find the short-winged individuals far inland until we reach New York and the New England States, and what is equally perplexing they do not there attack grain, but grass, whereas to the southward, except near the seacoast, it is the grain fields that are devastated by the long-winged form. In other words, throughout New England, New York, northeastern Ohio, northern Indiana, and the Dominion of Canada we have both the long and short winged individuals occurring together, but depredating almost or quite exclusively upon timothy (*Phleum pratense*).

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[a] Prof. H. A. Morgan, then entomologist of the State Experiment Station of Louisiana, writing under date of May 30, 1898, states that he has never found the brachypterous form of chinch bug in that State, and the writer did not observe a single individual of these among the many macropterous specimens taken by himself in that State.

[b] First Annual Report of the Entomologist of the State Experiment Station of the University of Minnesota, 1895, p. 26.

[c] Second Report on Noxious, Beneficial, and other Insects of New York, p. 278.

[d] Webster on Pestilence, Vol. I, p. 279.

In Bulletin 17, old series, Division of Entomology, U. S. Department of Agriculture, Dr. L. O. Howard, the author, stated that in 1886 a timothy meadow located near Wakeman, Huron County, Ohio, was considerably injured by chinch bugs. Since that time the species has never been reported from that section of the State, and the writer has found that depredations of that particular character are only committed by the more or less brachypterous race. This has been supposed to be largely confined to the northeastern portion of the State, though there seems to be no good reason why it should not appear in northwestern Ohio also. Owing to these facts this single occurrence in meadows, recorded by Doctor Howard, formerly puzzled the writer greatly.

During the fall of 1898 there came reports of very serious destruction of meadows in Huron and Lorain counties, which lie contiguous to each other, the cause being attributed to the dry, hot weather. But an examination of the meteorological records for that section revealed the fact that there had been no weather condition sufficiently severe to affect timothy meadows in that way. A survey of the affected meadows during early spring of 1899 revealed the presence of great numbers of brachypterous chinch bugs hibernating in these meadows, and the problem was solved. The species had doubtless been doing more or less injury since 1886, entirely unknown to the farmer or anyone else, thus showing the extent to which its secluded life in meadows protects it from observation. This section of the State since 1886 has been more largely devoted to dairying, and the meadows are not as rapidly rotated with other crops as when the cereals were grown more extensively.

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[a] Extract from correspondence of Prof. Franklin Sherman, jr., State entomologist.

In Ohio, which appears to be the frontier of destructive abundance. the line separating the habitat of the combined forms and that of the macropterous form, exclusively, indistinctly marks the line of separation between the most serious depredations and almost total immunity of attack on timothy meadows by chinch bugs. To the west and south of this a short-winged adult chinch bug is rarely seen, timothy meadows are seldom attacked, and then only where fields of small grain or corn are not in easy reach; as, for illustration, where the insect happens to breed in a wheat field surrounded by timothy, and, when the grain is harvested, there is no other recourse left it but to attack the grass. In the opposite direction from our line, however, the conditions are quite the reverse. Here, while fields of wheat are occasionally badly injured, thousands of acres of timothy meadow have been entirely killed out from its attack.

The area of destructive infestation of timothy meadows seems to extend on the east in Ohio from Lake Erie to the Ohio River at the northernmost point of West Virginia, and on the west, in the vicinity of Sandusky, it extends only 25 or 30 miles from the lake shore. In limited numbers the area of distribution extends westward, probably narrowing gradually, around the lower end of Lake Michigan into northern Illinois, where it seems to be on the increase, though still far from common. As will be shown further on, this form is not likely to become destructive where timothy is grown in rotation with other farm crops.

So far as it is possible to determine, there are a considerable number of winged adults produced in this area every year—perhaps from 30 to 50 per cent some seasons—and these breed in the grain fields; but at wheat harvest, instead of migrating to the corn, as is done elsewhere, they go by preference to the timothy meadows. In western New York, where both the long and short winged forms occur, Mr. Van Duzee wrote that he had never found an individual of either form in grain fields, but that they both literally swarm in timothy during some years. Doctor Lintner told the writer that in the serious outbreak of this pest in the meadows of New York in 1882 and 1883 about 20 per cent were of the short-winged form. Doctor Perkins has recorded an attack of the chinch bug in a timothy meadow in northern Vermont. Whether or not the short-winged form was the depredator in this last-named locality the writer is unable to say, but, generally speaking, the short-winged form is unknown at any considerable distance from the coast, except in Maine, New York, Ohio, Ontario, and northern Indiana, and but rarely does it occur in either form in the two latter localities.

Just why this short-winged form should occur in such abundance in the three States named is a matter that the writer is at present unable fully to explain; but it does seem that this difference in food habits as between the two forms and the limited distribution of the short-winged form inland might open the way to a solution of the mystery. The writer believes that the insect is primarily a tropical macropterous species, and that it has followed the coast from South America along the Gulf and Atlantic northward to Cape Breton, and along the Pacific coast to San Francisco and possibly beyond; also that it spread from northern Mexico and Texas northward as far as Winnipeg, subsisting upon the native grasses, and in the meantime spreading also to the eastward to northern Indiana and Ohio.

On the other hand, from the Atlantic coast there has originated a tide of diffusion the trend of which has been westward, the bugs here partaking more of the nature of their seashore ancestors, more or less of them being of the short-winged form, which their less nomadic habit has served to further emphasize. This tide of diffusion has encountered what the western tide did not, at least until much later, namely, the timothy meadows of the Caucasian agriculturist, and, adapting itself to this food plant, has held closely to it, thus avoiding the necessity of seasonal migration. In northeastern Ohio and possibly in northern Indiana and northern Illinois the western tide of diffusion has met the eastbound tide and is perhaps amalgamating with it. (See map, fig. 17, illustrating supposed direction of diffusion of chinch bug.)

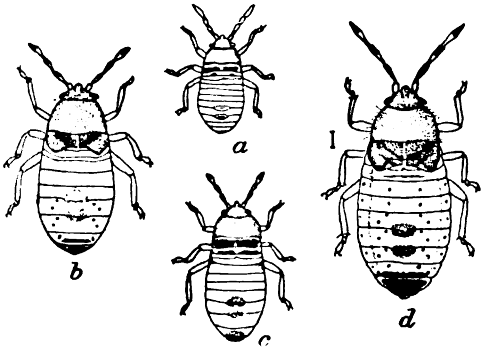

FIG. 18.—*Blissus doriæ*: *a*, first nymph; *c*, second; *b*, third; *d*, fourth. (From illustrations prepared in the Bureau of Entomology.)

Although not at all conclusive evidence, it might be added that the single specimen taken at Winnipeg by Doctor Fletcher was of the macropterous form, while the single example taken by Mr. Van Duzee at Muskoka, Canada, was of the brachypterous form; and this, with the fact that the specimens from the island of Grenada were of the former and the Florida coast specimens of the latter exclusively, shows that latitude and climate have no effect.

HABITS OF THE EUROPEAN SPECIES, BLISSUS DORÆ FERR.

Prompted apparently by a review of one of the writer's papers read before the eighth annual meeting of the Association of Economic Entomologists at Buffalo in 1896, Prof. Karl Sajö, formerly of the Kg. Ung. Staatliche Entomologische Versuchsstation, at Budapest, published a short paper on "*Unser Blissus doriæ*,"[a] which is so full of interest that the writer has reproduced it here, together with figures of the larval, pupal, and adult stages of the insect (figs. 18 and 19).

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[a] Illustr. Wachenschrift für Entomologie, Vol. II, pp. 449–451, July 18, 1897.

Professor Sajö writes as follows:

> In the article on the eighth annual meeting of the Association of Economic Entomologists (No. 26, pp. 401–403, Illustr. Wochenschrift für Entomologie) the very instructive observations of Mr. Webster on the "chinch bug" (*Blissus leucopterus*) in the State of Ohio were discussed.
>
> In view of this communication I will give more in detail that which I have observed concerning our European species of this genus, namely *Blissus doriæ* Ferr.
>
> Like the North American larger species, the smaller European one appears in two forms, namely, the wingless and the winged. The first describer of this species, Ferrari, in Genoa, recognized only the wingless form, which with its aborted wings looks very much like Hemipteron-nymphs, and probably by all entomologists who previously saw it was not considered as a sexually developed adult, but only the immature form of some already known species. I discovered the winged form seventeen years ago (1880) in the steppes sand desert, called "Nyires" of the Kis-Szent-Miklos, and described the same.[a]
>
> I at that time made known the characters of the immature forms, which can not be confused with the individuals which have reached complete sexual development, in that the immature individuals are vermilion red while adult individuals are dark brown. It is interesting that the relationship between the winged (macropterous) and the wingless (brachypterous) individuals of the American and European species is very different. For while in America those individuals which reach maturity are almost always winged, with us in Europe they are in general only short-winged, and individuals capable of flight are not observed: and the fully developed macropterous individuals were not thus far, according to my knowledge, found in any other place than in the central Hungarian sand dunes already named, and here they occurred only on a single little portion which only measured a few paces in diameter. It was a "Dunenhugel" (sandy hill) covered with high, scattered poplars, whose fallen, dried foliage sparsely covered the ground.

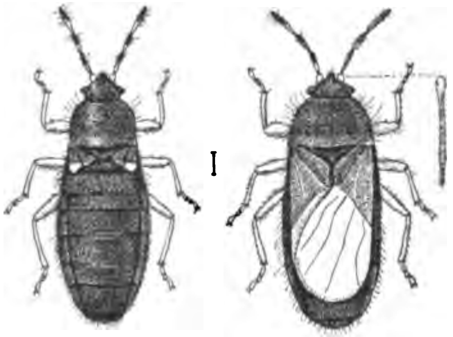

FIG. 19.—*Blissus doriæ*: Wingless form at left; winged form at right. (From illustration prepared in the Bureau of Entomology.)

> Here lived the colonies of *Blissus doriæ* on the bases of the bushy, growing grass, almost under the surface of the ground, and well concealed. The habits of the European species are also in the main similar to those of its American relative, since the latter also lives only on grasses, and during its development also lives very close to the surface of the ground.
>
> It is extremely remarkable that, even though *B. doriæ* is very widely distrib-

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[a] K. Sajö: "Die bisher unbekannte makroptere Form von *Blissus doriæ* Ferr." Entomolog. Nachrichten, 1880, p. 235.

uted here, and is met with not only on the "Flugsande" (sand drifts), but also in the hilly regions (e. g., on the southern exposure of the hill which stands between Duka and Szod, in the midst of bluffs or rolling hills), the winged specimens were to be found only on the very small "Blissus Island" under the poplars. But here also they were found but rarely, and only then when the transformation from the pupa to adult stage was in full force. When there were no more pupæ to be found, then also the search for long-winged individuals was in vain.

This appearance I explain in this way: That the winged examples, as soon as they were able to fly, quickly flew away and disappeared in order that they might serve as progenitors for new colonies.

But the place of discovery has since been transformed into an immense vineyard by the Government, whereby grass, poplars, and also *B. doriæ* had to disappear from thence. For four years I have, though seeking with the greatest diligence, been unable to get track of the winged specimens anywhere in this region, even though I know of a number of colonies of this species upon my own premises. While formerly I captured a few specimens each year and gave them partly to museums and partly to entomologists, I scarcely hope to attain such interesting finds in the future.

The difference just mentioned between those individuals capable of flight and those not capable of flight in our species and also in the transatlantic species can hardly be accidental, but may be sought for in the influences of environment.

Next there crowds to the front the fact that in North America *B. leucopterus* is continually subjected to the attack of its deadly fungus parasite to a high degree, and its colonies die out as soon as rainy, moist atmosphere prevails. Consequently, the Blissus species living there must always hunt new habitats and be wandering continually to far distant localities. For this wings are of course necessary, and only by means of these is the species enabled to sustain itself at such a high grade of importance that it can, now here, now there, become a veritable plague to agriculture.

With our European species it seems, on the contrary, in regard to many points to be otherwise; for, while her habits in the main are similar to those of her sister across the sea, yet there are found many important differences in their environment.

Blissus doriæ never congregates in such close masses as we read of in the American reports. It forms only insect islands, and even individual families seem to scatter out to some distance. In the steppes, moreover, the growth of grass is not matted, but stands in isolated bunches on the partially bare ground, the bunches being not infrequently separated by several paces.

Our species will not go into cultivated fields. I have never found even a single specimen among forage plants that have been sown, and already this condition is one of the reasons why the European species does not cluster together in such uninterrupted masses.

If, then, this is true the attacks of entomogenous fungi will hardly be able to create such havoc in *B. doriæ* as it does among *B. leucopterus* in America.

I have also during eighteen years never observed a wholesale dying off in the localities of occurrence known to me. The fungus *S. globuliferum* has perhaps never attacked it, and even though the European form were susceptible to similar pestilences, yet it is always hardly to be doubted that the fungus in the European homes of *B. doriæ* would not find favorable circumstances in that here during the period of development of this species in normal years great drought prevails. Rains lasting for a number of days, with continued moist and warm atmosphere, belong, with us, among the rarities, especially during the summer, and it is the young stages that are especially sensitive to the fungus attack, as has proven to be the case in America.

Among insects there may possibly be found Blissus enemies, even though the extremely penetrating odor of this bug, which is identical with that of the one living in beds in houses, may serve as a protection.

Taking all of this together, we observe that our European species is in less danger than the American, and that it is not subjected to catastrophes of total destruction, so far as has yet been observable in the stationary localities of occurrence in the open field, for I have never yet observed a sudden disappearance from the localities known to me. It is not necessary, therefore, for it to be continually hunting up new fields in which to thrive, and there was no apparent reason which in the struggle for existence would have given preponderance to the long-winged form; and so in time, in the generation of our species, which originally, perhaps, was full winged, the winged form became less and less numerous, until to-day we see almost entirely brachypterous individuals in the adult stage, exactly the same as in the bedbug, *Acanthia lectularia*, with this difference, that among the swarming masses of the latter nowadays not a single example with fully developed wings can be found, fortunately for us.

It is evident that the long-winged tendency in *B. doriæ* is disappearing, and the time may come when one will be unable to find any long-winged specimens. The designated dangers, on the contrary, against which the chinch bug must fight in North America require very strong migratory powers, and, consequently, well-developed wings, through which this especially significant difference between *B. doriæ* and *B. leucopterus* has been brought about.

As to the question whether or not our species shall be considered injurious, I can answer that it in no wise belongs to the entirely indifferent insects, but, on the contrary, contributes to the complete drying up of the rather sparse grasses of our steppe meadows during the summer. But since it has not thus far housed in the cultivated fields, it can not be placed upon the black list of serious depredators. Whether, moreover, in the future, when in consequence of the continued destruction of its herding meadows, its original food plants disappear more and more, *B. doriæ* may become, like so many other insect species, a depredator through necessity can only be conjectured. We have in this regard already recorded entirely too many remarkable transformations in the menu of other species to disregard entirely the possibility of a similar transformation in the life habits of our *B. doriæ*.

I wish also at this time to state, for the benefit of our many readers who may not be familiar with it, that in the dimorphic bugs, especially those in which the macropterous and brachypterous forms are found simultaneously, the former possess a much stronger and broader thorax than the latter. As a result of this difference in their physical structure, one is, when comparing them for the first time, easily inclined to designate them as two distinct species. In addition to this, there is in Blissus the strikingly beautiful coloration of the long-winged specimens, whose clavus and corium are light ocher-yellow, and the unusually large membrane, which is about twice as large as corium and clavus together and of an entirely milk-white color, making the long-winged individuals very prepossessing. The individuals with rudimentary wings, on the contrary, are of an obscure chocolate-brown. The larvæ are, as has already been stated, of a bright vermilion-red color, marked with black.[a]

With the foregoing, relative to the habits of an allied species of Blissus, it seems to the writer that we can the better understand how, under one set of conditions, all traces of a short-winged form might entirely disappear, while with another set of conditions this tendency might not only be perpetuated, but greatly emphasized. The two species, *B. leucopterus* and *B. doriæ*, are fully illustrated in all stages of development, as well as both macropterous and brachypterous forms. (See figs. on pp. 21, 22, 23, 83, 84.) For specimens of the latter species, *B. doriæ*, we are indebted to Professor Sajö.

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[a] Translated from the German by Mr. C. W. Mally.

PREVIOUS IDEAS ON THE DIFFUSION OF THE CHINCH BUG.

Formerly it was supposed that the chinch bug was a native of the Atlantic coast States, and that it made its way westward with the advance of civilization and the consequent progress of wheat growing. This theory was based upon the fact that the original description was drawn up from a specimen from the eastern shore of Virginia, collected by Mr. Say himself,[a] and, as before stated, the earliest destruction on record caused by this insect occurred in North Carolina, and it also committed great depredations in Virginia in 1839. Up to this time it had been supposed that it was a southern species, confined to the country south of latitude 40° north. But about this time chinch bugs appeared in Illinois, at Nauvoo, simultaneously with the settlement of the Mormons at that place, and as many supposed that this sect brought the bugs to the country with them, they were locally termed "Mormon lice."

In his second report, page 284, Doctor Fitch states that Mr. William Patten, of Sandwich, Dekalb County, Ill., informed him that the chinch bug first appeared in that locality in 1850. Mr. Patten, the father of Prof. Simon Patten, of the University of Pennsylvania, and the writer's father, settled in the immediate vicinity of Sandwich, Ill., in 1852. This was ten years after the Pottawattamie chief, Shabbona, and his tribe had migrated to Kansas or Nebraska, the writer does not remember which, but he does recall that it was about this time that the prairie fires ceased to occur over any wide areas, as the prairies were no longer fired annually by the Indians. The whole country was fast being occupied, and he well remembers that the settlers would decide upon a certain date on which they would set fire to the wild grass—in late autumn—so that all could be prepared. It may also be stated that there were very few timothy meadows at that time, as the wild grass afforded an abundance of hay, and not until years after did cultivated grasses come into general use. The writer also knows from personal experience and observation that with the decrease in prairie fires there came an increasing abundance of chinch bugs, which attacked the wheat fields of the farmer. Up to about 1862 these fields were largely of spring wheat, but about that time there was a rapid decline in the growing of this grain in northern Illinois. It seems possible that spring wheat might be more liable to attack from chinch bugs than fall wheat, as the former is, at the time when chinch bugs seek out their breeding grounds, more tender and inviting than the latter. Mr. Walter Young, writing from Galesville, Wis., states that his spring wheat was totally destroyed in 1897, though there had been none sown for ten years previous on the premises, and while the chinch bugs did not ordinarily do much injury, just as soon as spring wheat was sown they returned, as it were, and destroyed it.

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[a] The complete writings of Thomas Say, edited by Le Conte, Vol. I, p.

If spring wheat is so attractive to chinch bugs in spring as this would indicate, might it not be used for baits instead of millet, as is advised further on, in order to draw off the females in spring when seeking localities for oviposition?

This was in a country where there was comparatively little timber, the only forests, if such they could be called, being along the streams of water. The writer is confident that the chinch bug did not suddenly make its appearance in that section, but that with the increase of grain growing and the decrease of prairie fires its effects began to be more and more marked. Since then Prof. S. A. Forbes has secured information of the occurrence of these insects in sufficient numbers to attract attention as early as 1823 in southern Illinois, and within 25 miles of New Harmony, Ind., where Thomas Say resided and did the most of his entomological work.

REASONS FOR THE PRESENT THEORY OF DIFFUSION.

It seems to the writer that in all of this we have good grounds for supposing that the chinch bug occupied the most of the country prior to its occupancy by the white man, and that its first depredations were caused by its own advance coming in contact with the advance of civilization; and the simultaneous cessation of forest and prairie fires, with the displacement of the native grasses by large areas of wheat, so combined that the points of contact were in Illinois in the West and Virginia and North Carolina in the East. Not until within the last twenty-four years has the chinch bug been known to work serious and widespread injury east of the Allegheny Mountains, north of Virginia; and west of these mountains they have done scarcely any damage north and east of a line drawn from Chicago southeast to Cincinnati. Thousands of farmers in Ohio never saw a chinch bug until within the last thirteen years, and there are thousands more in northwestern Ohio, southern Michigan, and northern Indiana that, even yet, would not be able to recognize one were they to see it among their growing grain, or even if in abundance. But in considering this matter the fact must be borne in mind that timothy meadows are not burned over annually as were the forests and prairies, and the stubble does not die with the harvesting of the crop as in wheat, and therefore annual migrations are not necessary for the bugs in order to preserve life. In a timothy meadow the species may live on and reproduce year after year without ever being obliged to abandon the field. It was the wheat fields of the West that the eastbound macropterous tide of migration found confronting it in Illinois, and the smaller fields of grain and timothy meadows that the combined macropterous and brachypterous forms, more or less maritime and northbound, came in contact with along the Atlantic coast, while at the present time the two tides of migration have met in northeastern Ohio and northern Indiana.

In figure 17 is illustrated the theoretical directions and courses taken by each of these tides of migrations from the tropical regions, and in figure 1 the areas over which the species is now known to occur in Central and North America are indicated.

The writer believes that this same course of migration has been pursued, at least in the West, by the several species of Diabrotica, and especially *D. longicornis* Say, and to a less extent by another species of Hemiptera, *Murgantia histrionica* Hahn and possibly also by *Dynastes tityus* L., while the two latter with others are now working northward along the Atlantic coast. Besides, the westward tide of migration has been followed in all probability by *Pontia rapæ* L., *Phytonomus punctatus* Fab., *Hylastinus obscurus* Marshm., and *Crioceris asparagi* L., all of which have first become destructively abundant west of the Allegheny Mountains in extreme northeastern Ohio. The last four species, having been introduced from Europe, have undoubtedly migrated westward.

With an almost total lack of natural enemies in the United States, and with nearly all of its closest allies belonging in Mexico and the West Indies, it would seem as though we were in possession of additional evidence of the chinch bug's tropical origin. Besides this the name "chinch bug" is of Spanish origin, and this language has never been in common use in North America except in Florida and the country along the Mexican border.

The species certainly prefers the low country to the higher, and is seldom found in any numbers at an altitude of over 2,000 feet. Generally its habitat is 1,000 or lower. The altitude where it was found breeding on Volcan de Chiriqui, in Panama, is 6,000 feet; and of its habitations in Guatemala, San Geronimo, is 3,000 feet; Panzos, 2,000 feet; Champerico, sea level, and Rio Naranjo, about 2,000 feet, while in Colorado it occurs sparingly near Fort Collins at an elevation of 5,500 to 6,000 feet, while Professor Cockerell did not find it at all in the same State at elevations of 7,000 to 8,000 feet. On Mount Washington, in New Hampshire, it has been found only once, and this time by Doctor Packard, on the summit, which has an elevation of 6,500 feet.[a]

In his own experience, running over something like forty-five years, the writer has never witnessed serious injury by chinch bugs to crops on hilly land. It may be stated, however, that all of his studies of the insect have been carried on in a level country, Ohio being the most uneven and hilly, but even here all of the outbreaks observed were on level areas. In Minnesota, however, Doctor Lugger found that those grain fields which were most seriously injured were located near the edges of woods or on slopes. In some published observations of Professor Osborn, in Iowa, kindly placed at the writer's disposal by Doctor Howard, we find that in 1894 about 90 per cent of the infested fields examined by Professor Osborn were on high ground and about 80 per cent of the fields were hilly and ridges, in most cases the damage being first apparent upon the higher portions of the fields. The exceptions were where the chinch bug had evidently hibernated in wild grass and weeds occurring in the lower places, and these had been very dry for the twelve months preceding the damage of that year. Besides, both the Iowa and Minnesota areas are below 1,000 feet elevation.

The area over which the chinch bug is more especially abundant and destructive comprises such a variety of soils and geological formations that a study of these factors at once shows that neither has any material influence in the distribution of the species, at least in the United States. In its northernmost habitat it would not be at all surprising that it should prefer a sandy, rather than a clay, soil, the former being looser and warmer on or near the surface. (See fig. 10.)

In conclusion, then, on this point it may be stated that if *Blissus leucopterus* originated in the Western Hemisphere it was probably near the Tropics, and it is not impossible that its generic ancestors may have been carried from Europe or Africa by either the north equatorial or the main equatorial Atlantic currents, landing them on the northern shores of South America or on some closely located islands, from which the species has spread coastwise around the Caribbean Sea and the Gulf of Mexico, as previously indicated. In this connection it is interesting to note that specimens from Grenada, collected on the Mount Joy and Caliveny estates by Mr. H. H. Smith in June and September, show that the species here attains a large size and is more variable, both in size and markings, than is commonly found to be the case in the eastern United States.[b]

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[a] See paper by the writer on Origin and Diffusion of *Blissus leucopterus* and *Murgantia histrionica*, in Journal of Cincinnati Society of Natural History, Vol. XVIII, February, 1896.

[b] Uhler on Hemiptera-Heteroptera from St. Vincent and Grenada. Proc. Zool. Soc., London, 1894.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 70.

L. O. HOWARD, Entomologist and Chief of Bureau.

REPORT OF THE MEETING OF INSPECTORS OF APIARIES,

SAN ANTONIO, TEX., NOVEMBER 12, 1906.

ISSUED JUNE 17, 1907.

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1907.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., March 18, 1907.

Sir: I have the honor to transmit the manuscript of the proceedings of a meeting of inspectors of apiaries held in San Antonio. Tex., November 12, 1906. The meeting together and conference of the persons interested in the eradication of the diseases which are such a drawback to apiculture can not fail to bring out many points of importance. In such a meeting the subject is presented in a way which is not possible in articles written for journals devoted to bee keeping or for publication in other forms. There is no organization of inspectors and no funds are available by which these proceedings may be published, and since this meeting was to a large extent the result of the efforts of members of the Bureau of Entomology, and since these men took such an active part in the meeting, it would seem fitting that the proceedings be issued as a publication of the Department of Agriculture. I therefore recommend that this manuscript be published as Bulletin No. 70 of this Bureau.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

PREFACE.

The meeting of inspectors of apiaries was held on the Monday following the close of the National Bee Keepers' Association convention, November 12, 1906, at San Antonio, Tex., as a result of a call issued by Mr. N. E. France, inspector of apiaries for Wisconsin, Mr. W. Z. Hutchinson, inspector of apiaries for Michigan, and the writer.

The object of this meeting was to get together for consultation the men interested in the eradication and control of bee diseases. The closer cooperation of these men in their work can result only in good to apiculture and is greatly to be desired. Inspectors are chosen from among the practical bee men of the county or State, and the majority of them are familiar with their work on entering the service. They also accumulate a vast amount of information concerning diseases, most of which never reaches the bee journals or gains publicity in any way. A meeting of these men brings out many points which would otherwise remain unknown.

The meeting at San Antonio was most interesting and valuable, and since much that was said there has never been published it seems desirable to issue the proceedings of the meeting in the form of a bulletin to add to the knowledge of the bee-keeping public on bee diseases.

At the close of the meeting the writer was asked by the inspectors present to prepare a list of questions based on the laws now in force for the control of bee diseases. This list was prepared at once and a copy sent to each of the inspectors whose name and address could be obtained. At the same time the questions were taken up for detailed examination, and various persons were consulted on points of importance which arise. This work is not yet complete, for it has assumed proportions which were entirely unexpected at the beginning. It was originally intended that this discussion of the laws should be inserted as an appendix to the present report, but this would only delay the present publication. This aspect of the subject may therefore be submitted for future publication as soon as it can be prepared. It is very important that the best possible wording be used in a law to control bee diseases. The bee keepers of several States which do not have such laws are at present interested in this subject.

In the preparation of the manuscript for publication it was necessary to rewrite the articles by Doctor White and the present writer because the manner of presentation of these subjects in a meeting is not suited for publication. It was also necessary to edit the discussions, for the stenographic report was inaccurate in numerous places. It is believed, however, that even if the exact words of each person are not recorded, the meaning is the same as was intended to be conveyed. In certain places it has seemed desirable to enlarge somewhat on certain things which were said by the writer. This bulletin therefore can not be called a verbatim report, but it represents nevertheless the proceedings of the meeting.

It is hoped that similar meetings may be held in the future.

E. F. Phillips,
In charge of Apiculture.

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PLATE I. Portion of comb from colony infected with American foul brood . Frontispiece.

REPORT OF THE MEETING OF INSPECTORS OF APIARIES, SAN ANTONIO, TEX., NOVEMBER 12, 1906.

The meeting was called to order in Market Hall at 9.30 a. m. by Dr. E. F. Phillips, of the Bureau of Entomology, Department of Agriculture, Washington, D. C., who addressed the members as follows:

LADIES AND GENTLEMEN: Last summer it was my pleasure and privilege to visit a considerable number of the men at work on bee-disease inspection throughout the United States. After talking with them and going with them on inspection trips, it became evident that there is a great deal yet to be done in regard to the making of better methods of inspection in work against bee diseases, entirely apart from the scientific aspect of the subject.

On the 3d of last August Mr. N. E. France, inspector of apiaries for Wisconsin, who is attending this meeting, and Mr. W. Z. Hutchinson, the inspector of apiaries for Michigan, and myself met in Milwaukee, Wis., to talk over certain plans for making bee-disease inspection more effective. A circular letter, addressed to the persons now acting as inspectors in the various counties and States of the United States, was drawn up, suggesting that they meet in some place this fall to take up the work of bringing about more uniformity in the methods employed. The meeting of to-day is the result of that circular letter.

There are several things in work against bee diseases that are not at all clear to the bee-disease inspectors and others interested in the subject, and we wish to take some of them up for discussion to-day. We have with us Dr. G. F. White, of the Bureau of Animal Industry, U. S. Department of Agriculture, Washington, D. C., who has made a most thorough scientific study of the cause of bee diseases, and we shall first ask him to give his demonstrations and the result of his work. After he finishes I shall myself attempt to summarize the investigations of bee diseases which have previously been made by different men. It is perhaps well to take up the scientific aspect of this work first in order to make this clear, and later we shall take up the methods of inspection and treatment and the form of desirable laws controlling bee diseases.

It would perhaps be well for the inspectors of apiaries in the United States to be organized in some way so that there might be greater uniformity in the work and more harmonious cooperation. In Buffalo several years ago such an association was organized. At that time Mr. France, Mr. Hutchinson, and several others met together and organized an association of bee inspectors of the United States and Canada, but they had only an organization meeting and have never met since. Such an organization is desirable, but perhaps not all of those that would care to take part in the association are present.

Doctor White will now give us a demonstration on the brood diseases of bees, a subject on which he has made exhaustive studies.

THE BACTERIOLOGY OF BEE DISEASES.[a]

By G. F. White, Ph. D.,
Of the U. S. Department of Agriculture.

The object of this paper is to discuss briefly the science of bacteriology as it is used in the study of bee diseases and to give a summary of the results of my work on these diseased conditions.

In our discussion of bacteriology, or the science which deals with bacteria, it may be well to consider the subject under the following headings: (1) The nature of bacteria; (2) their distribution; (3) the methods for studying them, and (4) the results of their activity.

THE NATURE OF BACTERIA.

Bacteria are considered by some scientists to be a form of life lower than either animals or plants, but by the majority of authors they are looked upon as plants, and we shall so consider them at this time without going into a detailed discussion of the arguments in favor of such a view. Bacteria, often referred to as germs, microbes, or parasites, are, then, very small plants, so small indeed that they must be magnified 600 diameters or more before they can be seen.

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[a] At the meeting of the inspectors of apiaries Doctor White gave a demonstration of the work which he has done on the brood diseases of bees, showing, in illustration of his address, slides and cultures of the various bacteria under consideration. In view of this fact the stenographic report of his address is not clear on all points, since the demonstrations are lacking. It has, therefore, seemed best for Doctor White to write the article here published, giving a popular discussion of this phase of the work which would be intelligible without the demonstration. The substance of his remarks is all included in this paper except the part pertaining to the work of other bacteriologists, which is dwelt on at some length in the article herein published on "The Present Status of Bee Disease Investigation." This method of handling the subject in a published report will make the subject much clearer to those who did not attend the meeting at San Antonio.—E. F. P.

These plants, then, constitute an invisible flora, which we can see only by the use of a microscope of very high magnifying power. The morphology, or the structure, including form and size, is principally of two types, rod-shaped or cylindrical and round or spherical. The size of bacteria varies. Those which are rod-shaped usually measure from 1 to 3–6 microns in length and from one-half to 1 micron in diameter. A micron is the unit of measure for very small objects and is equivalent to $\frac{1}{25000}$ of an inch. For example, if a single bacterium of the rod form measures 2 microns, it would take 12,500 placed end to end to measure 1 inch in length. The spherical bacteria or cocci have about the same diameter as the rod-shaped ones.

Bacteria grow or multiply after a manner called fission; that is, after increasing in size they become constricted in the middle, which constriction finally severs the rod completely, and we then have two bacteria where there was but one before. Under favorable conditions for growth, each bacterium divides by fission every twenty minutes, or, in other words, gives rise to three generations in one hour. Such being their marvelous rate of increase, a little calculation will demonstrate that countless millions may be formed in a short time under favorable conditions, which are proper temperature, moisture, food in correct proportions, and the absence of much light. The temperature most favorable for the growth of a species of bacteria which is able to produce a diseased condition in animals is approximately the temperature of the animal which is affected by such species. Moisture is universally necessary. The food must not be too concentrated. Light inhibits the growth of bacteria. Direct sunlight is bactericidal; that is, it kills bacteria.

Many species produce spores when the conditions are not favorable for the multiplication of bacteria. These are small bodies formed in the bacteria (probably never more than one in a single bacterium) which are somewhat comparable to the grain in wheat and corn. These spores constitute a resting stage and usually also a very resistant stage, for high temperature and strong disinfectant solutions are necessary to kill them. It is these spores which probably make the control of the bee diseases more difficult. When the spores again gain access to a suitable "soil," for example, the body of an animal, they germinate and a new growth takes place as before.

Many species of bacteria have the power to move when they are in a liquid medium, while others do not. This ability to move is due to long, slender processes, which we call flagella, extending from the body of the bacterium.

THE DISTRIBUTION OF BACTERIA.

Bacteria are very widely distributed. Everyone is familiar with the very wide distribution of the higher members of the plant kingdom, as the trees, shrubs, flowers, and grasses, and we may for convenience refer to these plants as the visible flora. There is also an invisible flora, made up of the plants we can not see except with the aid of the miscrope. This flora includes the very minute plants referred to as bacteria, and also the yeasts and some fungi. The distinct species of plants which belong to the invisible flora outnumber by far those which are visible to the naked eye. These microscopic plants are found upon the surface of the animal body and along the digestive tract; they are found in the soil, in the food we eat, and in the water and milk we drink, but are not found within the normal tissues of animals and higher plants.

HOW BACTERIA ARE STUDIED.

The morphology or structure of bacteria is studied with the aid of a microscope of high magnification. Since the number of distinct species of bacteria is so extremely large, and since the shapes assumed by them are so few, it is obvious that many different kinds must look alike under the microscope. This is a point of considerable value in connection with bee-disease work, since in some cases attempts have been made by the use of the microscope alone to determine what species of bacteria was causing certain diseased conditions. With our present knowledge it is not possible to make a positive diagnosis of these diseases with the microscope alone. With the microscope we are able to determine usually only the genus to which any bacterium belongs. If we are trying to identify *Bacillus alvei*, for example, we are able with the microscope alone to say only that it is a Bacillus, since it is seen to be a straight rod. Some other means is necessary to determine the species (*alvei*) to which it belongs. For this purpose we use artificial media or " soils " in which pure cultures of the bacteria are inoculated or planted.

The media in common use are bouillon and sugar-free bouillon. gelatin, agar, and sugar-free bouillon to which has been added small amounts of various sugars known in chemistry as glucose, lactose. saccharose, maltose, and levulose. In addition to these media, use is made of potato, milk, and milk to which litmus has been added, so that the reaction—whether acid, alkaline, or neutral—may be noted. The bouillon is prepared from beef juice to which some peptone and salt are added. Sugar-free bouillon is similar, except that the muscle sugar has been removed. Gelatin is made from pure sheets of gelatin somewhat similar to that used in cooking, to which bouillon is added. The bouillon affords the food for the bacteria or other small plants, while the gelatin keeps the medium solid at ordinary temperatures. Agar-agar (or simply agar) is the dried stem of a certain seaweed which liquefies on heating; to this is added bouillon, as in the case of gelatin, which solution congeals, as does gelatin, on cooling. The milk used is cow's milk with the butter-fat removed. Before using, all these media are sterilized by heat to kill all bacteria or fungi which might be present.

Having prepared these soils in this way, before the inoculation of them the bacteria must be obtained in pure culture. By pure culture is meant the growth of one species only in a medium. Such a culture is obtained by diluting a small quantity of the material, e. g., decayed larvæ, containing the bacteria with a relatively large amount of liquefied agar, and then pouring it into a shallow sterile glass box (Petri dish). In this way we get only a few bacteria scattered throughout a thin layer of the medium. Each bacterium then begins to grow, and after a few hours it has produced a large number, which, being massed together, we are able to see with the naked eye. This mass of bacteria, having been produced from one individual, constitutes a colony, and such a colony can contain but one species, therefore we speak of it as pure. Pure cultures are then made by inoculations from such a colony. The next step is to identfy this species which we now have isolated from all other species. To do this we inoculate a few or all of the differential media mentioned above. After inoculating and growing the bacteria in these different media or soils at about the body temperature for a day or longer we observe the effect upon the various media produced by the growth of the bacteria and the appearance of the growth in or upon these media. All these phenomena and appearances we speak of as cultural characters. Having obtained in this way the cultural characters of a species of bacteria, we are able to classify it by comparing these cultural characters with the cultural characters of known species.

To illustrate this, let us take for example *Bacillus coli communis*, found normally in the intestine of man and many animals, including the intestine of the adult bee, *Bacillus alvei*, found in European foul brood, and *Bacillus larvæ*, found in American foul brood. *Bacillus coli communis* by its growth in bouillon causes the latter to become heavily clouded; *Bacillus alvei* makes it feebly clouded; while *Bacillus larvæ* does not grow at all in this soil and the bouillon remains clear. In gelatin *Bacillus coli communis* grows very well and does not liquefy the medium by its growth; *Bacillus alvei* grows very slowly and only feebly and liquefies the gelatin; while *Bacillus larvæ* does not grow at all in this medium. When *Bacillus coli communis* is planted on potato it produces a brownish growth; *Bacillus alvei* on this medium produces a lemon-yellow growth, and *Bacillus larvæ* fails to show any growth. When *Bacillus coli communis* is planted in milk there follows a rapid souring of the milk and a firm coagulation of the casein; *Bacillus alvei* produces a soft coagulum which is followed by a slow digestion or liquefaction of the casein; *Bacillus larvæ* does not grow in milk. In litmus milk, *Bacillus coli communis* produces a large amount of acid, which is indicated by the change of the litmus to the red color; *Bacillus alvei* produces no marked change in reaction, and *Bacillus larvæ* does not grow in this medium. In the bouillons to which the sugars, glucose, lactose, saccharose, etc., have been added, there is produced by the growth of *Bacillus coli communis*, gas, and a large amount of acid; *Bacillus alvei* does not produce gas, and only a small amount of acid by its growth in the media containing sugars, while *Bacillus larvæ* does not grow when planted in these "soils." (I shall speak later of a medium upon which *Bacillus larvæ* will grow.)

It is by these differences which we observe in the growth upon the various media and the effect produced upon the different media by the growth of the bacteria that we are able to determine one species of bacteria from another.

THE RESULTS OF THE ACTIVITY OF BACTERIA.

In the consideration of this question it is convenient to divide the bacterial flora into two groups—nonpathogenic, or those which do not produce disease, and pathogenic, or those which do produce disease. Some of the nonpathogenic bacteria are economically very important as scavengers. The bodies of dead animals and plants are largely brought to decay by them. The flavors of butter, cheese, and wines are thought to be improved by the growth of bacteria or other micro-organisms—the fungi and the yeasts. Others of these micro-organisms ruin the food, causing the souring of milk, the spoiling of fruit, etc. Many diseases in man and animals are known to be caused by bacteria, as tuberculosis, diphtheria, glanders, and anthrax.

I wish now to speak briefly of how bacteriology has been used in the study of bee diseases, and to summarize the results which have been obtained. For a more detailed account you are referred to a bulletin issued by the Bureau of Entomology of the United States Department of Agriculture—Technical Series, No. 14, "The Bacteria of the Apiary, with Special Reference to Bee Diseases," issued November 6, 1906.

From what has been said one would naturally infer that in every apiary, whether diseased or not, there are on the hives, combs, and bees a large number of bacteria that are perfectly harmless. If one is trying to find in a diseased apiary the species of bacteria which is the probable cause of the trouble, what is the method of procedure? Suppose there were two herds of cattle on adjoining farms and the cattle on one farm were dying while those on the other remained well. If it were suspected that some plant which the cattle were eating was the cause of death, naturally the plant would be selected which was found on the farm where the animals were sick and which was not found on the farm where the animals remained well. This is exactly the kind of reasoning used when we are looking for the bacteria which are causing the diseases among bees. This necessitates, as you see, the study of all the bacteria which are present in any apiary, whether diseased or not, as well as those in diseased apiaries.

At the time we began the work on bee diseases, in June, 1902, the disorders which were causing the greatest trouble were known to bee keepers as black brood, foul brood, pickle brood, and paralysis. After the study of a large number of samples of brood affected by disease which was being called black brood and the finding of *Bacillus alvei* in all of them, it is very clear that this disease is the same as that investigated by Cheyne in 1885 and called by him "foul brood;" he first described *Bacillus alvei.* "Black brood" was a name given by Dr. William R. Howard, of Fort Worth, Tex., to a disease which he thought existed in New York State, and he described as its cause *Bacillus milii.* After a careful search in New York State for a disease containing *Bacillus milii* we were unable to find it, and there seems to be no ground for the description of a new disease. What has been called black brood by Doctor Howard is obviously the type of foul brood which we now distinguish as European foul brood.

In the decaying larvæ and dried scales found in the cells in the disease which was receiving the name of foul brood there were seen by the use of the microscope a very large number of the spores of bacteria, and in the larvæ in the early stage of the disease there were observed bacteria in the rod form. When these spores were planted upon the media or soils which have been explained earlier in this paper, they would not grow. It became necessary, then, to devise a soil in which the growth could be obtained. After a number of unsuccessful attempts, a medium or soil was made from healthy bee larvæ in which the spores would germinate and the bacteria would grow. By a study of this species, which was found in the dead larvæ of this disease and which was not found in the healthy apiary, it was evident that it was not *Bacillus alvei*, and, since *Bacillus alvei* is not present at all, we know that this disease is not the foul brood which Cheyne had reported in his work in 1885. Since it is not this type of foul brood, what could it be? By carefully reviewing all the work which had been done by others, the conclusion was inevitable that this diseased condition had not been described properly from a bacterial standpoint as a disease separate and distinct from the foul brood of Cheyne, but that the mistake had been made for a long time of calling two different and distinct diseases which affected the brood of bees by one name. This condition was reported to the New York State department of agriculture in a report to that department made in January, 1903, and another in January, 1904. In the latter report this condition, for want of definite information, was referred to as "X brood" and the bacillus as *Bacillus X*. At the suggestion of Dr. E. F. Phillips, of the Bureau of Entomology, United States Department of Agriculture, it was thought best for very good reasons to retain the name foul brood in the name of each disease and add a qualifying word to designate the difference between the two diseases. "European" is added to foul brood to designate the disease which Cheyne studied in England (Europe) in 1885, and "American" is added to the foul brood which was first studied in the United States (America). We distinguish, then, European foul brood and American foul brood. Both of these diseases of the brood of bees seem to be found in Europe as well as America. It must therefore be remembered that these names do not put any stigma on either country, Europe or America, but, on the contrary, Europe is thereby given the credit of having first studied the European foul brood and America for having first studied American foul brood.

In a study of the so-called "pickle brood" we are unable to suggest from a bacteriological standpoint any cause for the disease. A study has been made of the bacteria found upon the healthy adult bee and those found in the intestine and also the bacteria found upon and within the adult bees suffering with palsy or paralysis, but so far no suggestion can be made from a bacteriological standpoint as to the cause of this disorder of the adult bee.

To conclude, I shall read, with your permission, the summary of the work reported in the bulletin referred to above.[a]

SUMMARY TO PART I.

The results of the study of the bacteria found normally in the apiary may be briefly summarized as follows:

(1) The temperature of the hive approximates that of warm-blooded animals.

(2) Upon adult bees and upon the comb there occurs quite constantly a species of bacteria which we refer to in this paper as *Bacillus A*, and which, it is believed, is the organism that some workers have confused with *Bacillus alvei* which is universally present in European foul brood.

(3) There occurs very constantly in the pollen and intestine of adult bees a species here referred to as *Bacillus B*.

(4) From the combs *Bacterium cyaneus*, *Saccharomyces roseus*, and a Micrococcus referred to here as *Micrococcus C*, have been isolated and studied.

(5) Honey from a healthy hive is, as a rule, sterile.

(6) The normal larvæ are, as a rule, sterile.

(7) There is an anaërobe found quite constantly in the intestine of the healthy honey bee. It is referred to in this paper as *Bacterium D*.

(8) From the intestine there have been isolated and studied the following micro-organisms: *Bacillus cloacæ*, *Bacillus coli communis*, *Bacillus choleræ suis*.

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[a] Technical Series, No. 14, Bur. Ent., U. S. Dept. Agric.

Bacillus subgastricus, Bacterium mycoides, Pseudomonas fluorescens liquefaciens, and two referred to as *Bacillus E,* and *Saccharomyces F.* Others less frequently present have been isolated, but not studied.

(9) In two samples of brood with unknown disease there was found a species of yeast plant here referred to as *Saccharomyces G.*

SUMMARY TO PART II.

Following is a brief summary of the results of the present investigation of bee diseases:

(1) There are a number of diseased conditions which affect the apiary.

(2) The disease which seems to cause the most rapid loss to the apiarist is European foul brood, in which is found *Bacillus alvei*—first isolated, studied, and named by Cheshire and Cheyne in 1885.

(3) The distribution of *Bacillus alvei* in the infected hive is as follows:

(*a*) The greatest number of infecting germs are found in the bodies of dead larvæ.

(*b*) The pollen stored in the cells of the foul-brood combs contains many of these infecting organisms.

(*c*) The honey stored in brood combs infected with this disease has been found to contain a few bacilli of this species.

(*d*) The surface of combs, frames, and hives may be contaminated.

(*e*) The wings, head, legs, thorax, abdomen, and intestinal contents of adult bees were found to be contaminated with *Bacillus alvei.*

(*f*) *Bacillus alvei* may appear in cultures made from the ovary of queens from European foul-brood colonies, but the presence of this species suggests contamination from the body of the queen while the cultures are being made and has no special significance.

(4) The disease which seems to be most widespread in the United States we have called American foul brood, and the organism which has been found constantly present in the disease we have called *Bacillus larvæ.* This disorder was thought by many in this country and other countries as well to be the foul brood described by Cheshire and Cheyne, but such is not the case.

(5) From the nature of American foul brood it is thought that the organism has a similar distribution to that of *Bacillus alvei.*

(6) It appears that European foul brood was erroneously called "New York bee disease" or "black brood" by Dr. William R. Howard in 1900.

(7) There is a diseased condition affecting the brood of bees which is being called by the bee keepers "pickle brood." No conclusion can be drawn from the investigation so far as to the cause of the disease.

(8) *Aspergillus pollinis,* ascribed by Dr. William R. Howard as the cause of pickle brood, has not been found in this investigation and is not believed by the author to have any etiological relation to the so-called "pickle brood."

(9) Palsy or paralysis is a diseased condition of the adult bees. No conclusion can yet be drawn as to its cause.

(10) Formaldehyde gas as ordinarily used in the apiaries is insufficient to insure complete disinfection.

CONCLUSIONS.

In a paragraph the author wishes, if possible, to present the status of the bee diseases in this country. It should be remembered, firstly, that "black brood" can now be dropped from our vocabulary, and probably does not exist; secondly, that the term "foul brood" was being applied to two distinct diseases. One of these diseases we now refer to as European foul brood, because it first received a scientific study from a European investigator. We refer to the other disease as American foul brood, because it was first studied scientifically in America. There is one more disorder in the brood of bees which has attracted considerable attention—the so-called "pickle brood." There are, then, these three principal diseases: European foul brood, American foul brood, and the so-called "pickle brood."

Doctor PHILLIPS. We surely have all been glad to listen to Doctor White in his most interesting account of his work. It will be well at this time to ask him any questions concerning this work which may have come to mind. Before opening this subject for discussion I wish to say that after this discussion I shall take up in detail the works which Doctor White has criticized. Consequently, if you have no objection, we will hold over until later any discussion of these papers.

Mr. C. P. DADANT. As I understand it, there exist these two bacilli (*Bacillus alvei* and *Bacillus larvæ*) and also *Bacillus mesentericus vulgatus*. Have you samples of all three of the bacilli?

Doctor WHITE. Yes, sir; that (pointing to slides) is *Bacillus larvæ;* that (showing cultures) is the *Bacillus alvei*, and the next, *Bacillus mesentericus*. There are a number of varieties of *Bacillus mesentericus*, and *vulgatus* is one of them.

SYMPTOMS OF BEE DISEASES.

Mr. DADANT. Will you please give us a description of the two diseases—that is, of the conditions arising when *Bacillus larvæ* and *Bacillus alvei* are present in the combs?

Doctor WHITE. I should like to ask Doctor Phillips to answer that question.

Doctor PHILLIPS. I shall simply quote from Doctor White's bulletin. There was issued from the Bureau of Entomology some time ago a small circular, Circular No. 79, entitled "The Brood Diseases of Bees," and in this circular was included a description of the two diseases which Doctor White has been studying. Doctor White was kind enough to quote in his bulletin from Circular No. 79, and I shall read the descriptions.

AMERICAN FOUL BROOD.

American foul brood (often called simply "foul brood") is distributed through all parts of the United States, and from the symptoms published in European journals and texts one is led to believe that it is also the prevalent brood disease in Europe. Although it is found in almost all sections of the United States, there are many localities entirely free from disease of any kind.

The adult bees of an infected colony are usually rather inactive and do little toward cleaning out infected material. When the larvæ are first affected, they turn to a light chocolate color, and in the advanced stages of decay they become darker, resembling roasted coffee in color. Usually the larvæ are attacked at about the time of capping, and most of the cells containing infected larvæ are capped. As decay proceeds, these cappings become sunken and perforated, and, as the healthy brood emerges, the comb shows the scattered cells containing larvæ which have died of disease, still capped. The most noticeable characteristic of this infection is the fact that when a small stick is inserted in a larva which has died of the disease, and slowly removed, the broken-down tissues adhere to it and will often stretch out for several inches before breaking. When the larva dries, it forms a tightly adhering scale of very dark-brown color, which can best be observed when the comb is held so that a bright light strikes the lower side wall. Decaying larvæ which have died of this disease have a very characteristic odor, which resembles a poor quality of glue. This disease seldom attacks drone or queen larvæ. It appears to be much more virulent in the western part of the United States than in the East.

EUROPEAN FOUL BROOD.

European foul brood (often called "black brood") is not nearly as widespread in the United States as is American foul brood, but in certain parts of the country it has caused enormous losses. It is steadily on the increase and is constantly being reported from new localities. It is therefore desirable that bee keepers be on the watch for it.

Adult bees in infected colonies are not very active, but do succeed in cleaning out some of the dried scales. This disease attacks larvæ earlier than does American foul brood, and a comparatively small percentage of the diseased brood is ever capped. The diseased larvæ which are capped over have sunken and perforated cappings. The larvæ when first attacked show a small yellow spot on the body near the head and move uneasily in the cell. When death occurs, they turn yellow, then brown, and finally almost black. Decaying larvæ which have died of this disease do not usually stretch out in a long thread when a small stick is inserted and slowly removed. Occasionally there is a very slight "ropiness," but this is never very marked. The thoroughly dried larvæ form irregular scales which are not strongly adherent to the lower side wall of the cell. There is very little odor from decaying larvæ which have died from this disease, and when an odor is noticeable it is not the "glue-pot" odor of the American foul brood, but more nearly resembles that of soured dead brood. This disease attacks drone and queen larvæ very soon after the colony is infected. It is as a rule much more infectious than American foul brood and spreads more rapidly. On the other hand, it sometimes happens that the disease will disappear of its own accord, a thing which the author never knew to occur in a genuine case of American foul brood. European foul brood is most destructive during the spring and early summer, often almost disappearing in late summer and autumn.

GEOGRAPHICAL DISTRIBUTION.

Mr. France (Wisconsin). When I was with Doctor Phillips and Inspector Hutchinson in Michigan studying the difference between American and European foul brood, it occurred to me that it was possible to bring together at this time specimens of diseased brood from different localities. In my own city (Platteville, Wis.) I found samples of diseased comb and had reserved them for this meeting, but unfortunately three of the four samples in my possession contained moth larvæ, and it was impossible to tell anything about the disease. The only one that I still have is now in my grip.

Mr. Dadant. Where were those samples from?

Mr. **France**. From Michigan.

Doctor **Phillips**. Our first accurate knowledge of European foul brood in the United States was the epidemic in New York State, and most bee keepers still look on the disease as still being confined to that State. However, European foul brood is now found in New York, Vermont, Massachusetts, Connecticut, New Jersey, Pennsylvania, Ohio, West Virginia, Michigan, Indiana, and Illinois. Reports have been received at the Bureau of Entomology from all those States. The disease is rapidly going west.

COMPARISON OF DISEASES.

Mr. **William Atchley** (Texas). Which of the two diseases is considered worse, the American or the European foul brood?

Doctor **Phillips**. That is a point which was simply suggested in the descriptions just read. European foul brood spreads more rapidly than the other, but at the same time it will at times absolutely disappear of its own accord, which is something that the American foul brood seems not to do. We have these two factors over against each other, and I should as soon try to eradicate one disease as the other. As far as loss is concerned there seems to be very little difference.

Mr. J. Q. **Smith**. (Illinois). How many specimens have been sent to the Bureau of Entomology from Illinois?

Doctor **Phillips**. Two, I believe.

Mr. **Smith**. I was in correspondence with some of the persons having this disease among their bees, and I advised them to send samples to you.

INFECTION IN HONEY.

Mr. R. A. **Holekamp** (Missouri). Have the bacteria of both diseases been found in honey from infected hives?

Doctor **White**. We believe that the infecting agent may be present in honey in each case, since the experience of the bee keeper has been that the infection of a healthy colony has followed the feeding of honey from hives affected by either disease.

INFECTION OF LARVÆ.

Mr. A. H. **Anderson** (Utah). How does the larva become infected?

Doctor **Phillips**. The manner by which this is brought about is not all entirely certain, but the facts would tend to show that it is through feeding on infected material.

Doctor **White**. It would appear that internally the contamination is caused by being carried by worker bees. As they move over the combs and clean out the cells they come in contact with contaminated material. On any part of the body one can find *Bacillus alvei;* so I shall leave it to you, as you are more conversant with bees.

Doctor PHILLIPS. The bacteria in a diseased colony are present everywhere. They are found all over the adult bees, on the queens, on the outside of the comb, and every place else. They do not, however, grow in honey; they quickly go from the rod condition to the spore condition and remain in the latter condition indefinitely when in honey. According to the statement just made, it would seem that a bee from an infected hive would always carry disease. The fact is, however, that if the bees have been away from this infection for some time they will not transmit the disease. Give them a new clean hive with no food, so that all the honey is used up from the inside of the body. The infection from the outside does not seem to spread the disease if no brood is reared for a few days.

Mr. SMITH. I believe that the reason why the bee loses the infection is because a certain time elapses before the comb is drawn out and young larvæ are present which are large enough to become infected. But I know this fact: If you shake bees from a diseased colony onto combs that contain healthy larvæ, you might as well leave the larvæ, for disease at once appears. I have tried that.

BACTERIA IN QUEENS.

Mr. DADANT. In either case have the bodies of queens been inspected?

Doctor WHITE. The bodies of queens have been inspected, and while the internal organs contained these organisms, the ovaries seldom do, and where *Bacillus alvei* is found in the ovary, or in our cultures made from the ovary, they occur very seldom, and the probability is that they get there through contamination in making the cultures rather than from being found in the ovary itself. The ovaries are very small and one must work with instruments that are sufficiently large to handle. It is almost impossible to take cultures from the ovary and not get contamination from the outside.

"BLACK BROOD."

Mr. H. H. ROOT (Ohio). I thought I understood Doctor White to say that the disease called black brood has not been found in New York.

Doctor PHILLIPS. What Doctor White said was that there is no such thing as black brood. The name black brood was a blunder.

INFECTION CARRIED TO FLOWERS.

Mr. SMITH. Then if, as you say, the contamination is always present on the adult bees from diseased colonies, why is it not possible to carry it to the blossoms and leave it on the pollen, so that the next bee visiting the same flower would carry germs to its hive?

Doctor PHILLIPS. It is, of course, possible, but highly improbable.

VITALITY OF SPORES.

Mr. **France**. As to the duration of this bacillus in the spore form, how long can it remain in honey and still have vitality to grow under proper conditions?

Doctor **Phillips**. I have never determined any limit. It is known that very old honey from an infected hive will transmit disease to a colony.

Mr. **France**. In my State (Wisconsin) we had an experience bearing on this point where combs contained American foul brood. The bees had died, leaving the combs containing dead dried-up larvæ, and the owner, anxious to start in bees again, put the hives away in the granary, and four years afterwards hived bees on them and American foul brood started anew.

Mr. D. H. **Coggshall** (N. Y.). When honey was shipped from Cuba several years ago and scattered all over the United States, if it was left where bees from this country could get to it, the disease was certainly scattered broadcast.

PUBLICATIONS ON BEE DISEASES.

Doctor **Phillips**. I desire at this time to announce the publication of three pamphlets on bee diseases issued by the Bureau of Entomology. Circular No. 79, "The Brood Diseases of Bees," was issued three or four weeks ago. I have just this morning received copies of a paper by Doctor White, Technical Series, No. 14, entitled, "The Bacteria of the Apiary, with Special Reference to Bee Diseases." This was issued on November 6, and was received here this morning. I have also a pamphlet here from the Bureau of Entomology containing all the laws in force relative to bee-disease inspection. This is a reprint from Bulletin No. 61, "The Laws in Force Against Injurious Insects and Foul Brood in the United States." A recent order of the Secretary of Agriculture has put a stop to the free distribution of bulletins, but they can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. The price of Technical Series, No. 14, is 10 cents.

The following paper was then read by Doctor Phillips:

THE PRESENT STATUS OF THE INVESTIGATION OF BEE DISEASES.

By E. F. Phillips, Ph D.,
Of the U. S. Department of Agriculture.

I wish to take up two or three phases of this work about which Doctor White has been speaking, and to add some additional points. In regard to the history of the investigation of bee diseases prior to 1885, I can do no better than to quote the historical résumé contained in a paper by Prof. F. C. Harrison, entitled "Foul Brood of Bees," published as Bulletin 112 of the Ontario Agricultural College:

> In all probability the first definite reference to foul brood is by Aristotle (Historia Animalium, Book IX, ch. 27), who mentions an inertness which seizes the bees and causes a bad smell in the hive. He also suggests that bees are liable to become diseased when the flowers on which they work are attacked by blight. Bee dysentery as well as foul brood causes a bad odor; but in the former disease the spotting and consequent smell are usually outside the hive.
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> Columella (De Re Rustica, Book IX, ch. 13) mentions a bee pestilence and an annual distemper which seizes the bees in spring. Pliny (Natural History, Book XI, ch. 19, A. D. 79) writes of a disease of bees, but as he uses the same term as Aristotle he has probably copied it from the latter author.
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> Schirach (Histoire des Abeilles, ch. III, p. 56, La Haye, 1771), in 1769, was the first writer to name the disease "foul brood." He says:
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>> It is dangerous and a most destructive disorder to the bees, a genuine plague when the complaint has reached a certain stage. The cause can be attributed to two sources: (1) The putrid (or tainted) food with which the bees feed the larvæ for lack of having better. (2) By the mistake of the queen bee in misplacing the larvæ in their cells, head upside down. In this position the young bee, unable to get out of its prison, dies and rots away.
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> Further, Schirach clearly distinguishes between foul brood and chilled brood, and mentions the fact that putrefaction follows the death of the brood from frost, but in this case "it is only an accident and not a disease."
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> The remedy Schirach recommended was to remove all diseased combs from the infected hives and to keep the bees fasting for two days, after which they are furnished with other cakes of wax and a suitable remedy given, "as a little hot water mixed with honey, nutmeg, and saffron, or a syrup composed of equal parts of sugar and wine seasoned with nutmeg." Thus, as Cowan (Journal of the Royal Agricultural Society, Vol. VI, Part IV, 1895) remarks: "We had given us nearly one hundred and thirty years ago a method of cure almost identical with what is by some claimed as new to-day."
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> Tessier (L'Encyclopedie Methodique, Abeille, p. 32, 1765) about the same time as Schirach says that when the larvæ die in their cells it causes an infection in the hive which makes the bees sick. It is then necessary to drive away or sometimes move the bees from the hive, and to take care to fumigate the infected hive if it is going to be used again. It is necessary, in order to avoid the same inconvenience, to take out the parts of the comb that may be moulded by reason of the dampness. Duchet (Culture des Abeilles, p. 315, Vevey, 1771), who wrote on bees in 1771, does not mention any disease that can be certified as foul brood, but he describes bee dysentery.
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> Della Rocca (Traite Complet sur les Abeilles, Vol. III, p. 261, Paris, 1790), vicaire-general of Syra, an island in the Levant, relates with much detail the history of an epidemic of foul brood, which caused great destruction in the island during the years 1777 to 1780. Della Rocca describes very minutely the symptoms, destruction, and mistakes that were made in attempting to combat the disease. He says:
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>> The disease manifests its presence by defects in the combs filled with brood, and which only contain a putrid mass; instead of the bee pupæ there is only rottenness in the cells, which, however, being capped, always preserve a healthy appearance. If these cells are broken open, a blackish liquid flows out, which spreads the infection through the hive. This disease only manifests itself in cells which contain a nearly mature larva or a capped one. The bees themselves remain in good health, and work with the same activity, but their numbers decrease daily. This disease, however, was not so general in a hive

but that a small portion escaped. Some new bees emerged, but in too small numbers to supply the daily losses. Thus a hive attacked by this scourge will perish from scarcity of population. At first it was not noticed that this disease was epidemic, and the hives emptied by death of the bees were filled with fresh swarms, and these contracted the same disease and perished. Yet another mistake was made. The remains of the hives that were lost were taken into the streets of the town to expose them to the sun in order to extract all the wax, and the bees from the neighborhood sucked up the honey, caught the disease, and communicated it to other hives, and all, without exception, perished in a short time. The epidemic having reached the island spread everywhere, and the mortality among the bees was general, either from eating infected honey, or from stopping up the infected combs, or from the bees nourishing their brood on infected honey.

Della Rocca criticises Schirach's statement regarding the misplacement of the larvæ by the queen as a cause of the disease, because "everybody knows that the queen has nothing else to do but deposit eggs. These are then cared for and nourished by the bees; and when the larva is nearly ready to change into the pupa, the bees close the cell, and every position which is given the larva depends on their good pleasure and not on the queen's." Della Rocca himself thinks that "some pestilential blight had without doubt corrupted the quality of the honey and the dust from the anthers," and recommends "burning everything without pity, as there is no other resource when the disease is well established, as the pest is without doubt the most terrible in the natural history of bees."

Neither Wildman (Treatise on the Management of Bees, London, 1796), Keys (Ancient Beemasters Farewell, London, 1796, Woolridge), Needham (Brussels Memoirs, Vol. II, 1780, Rhein), Reaumur (Memoirs pour Servir a l'Histoire Naturelle des Insectes, T. V., p. 1734), and other authors about the same time (latter end of the eighteenth century) mention this disease.

Bevan (The Honey Bee, London, 1827) names the disease "pestilence," and also quotes Schirach's name, "foul brood," and says regarding it that the "pestilence has been attributed to the residence of dead larvæ in the cells, from a careless deposition of ova by the queen. * * * It has also been attributed to cold and bad nursing; that is, feeding with unwholesome food."

Nothing further of note appears in bee literature till the year 1860, when Doctor Leuckhart (Bienen Zeitung, Eichstadt, 1860, p. 232) writes that he was formerly of the opinion that foul brood was caused by the same fungus (*Panhistophyton ovatum*) which is noticed in a disease of the silkworm, but now, after observation and experiment, is quite certain that the disease is caused by neither vegetable nor animal parasite. He also notes that the term "foul brood" is applied to a number of diseases affecting bees.

Molitor Muhlfeld (Bienen Zeitung, Eichstadt, 1868, p. 95) recognizes two forms, one contagious and the other not contagious, and thinks that the only cause of contagious foul brood is a fly (*Ichneumon apium mellificarium*) which lays its eggs on the young larvæ of the bee.

A discovery of note was Preuss's (Bienen Zeitung, 1868, p. 225), in 1868. He contradicts Muhlfeld's statement about the fly, and states that foul-brood cells can be detected by the sunken cap. With a microscope magnifying 600 diameters he found small, dust-like bodies, with a diameter of $\frac{1}{500}$ mm., belonging to the genus *Cryptococcus* (Kutzig), and called the specific form *alvearis*, likened it to the fermentation fungus (*Cryptococcus fermentum*), and thought that the last germ gained access to the young bee and changed to *Cryptococcus alvearis*. He notices that many experts lay the cause of the disease to fermenting food, but the larvæ are easily contaminated by the fermentation fungus, which is always present in the air. He also mentions the enormous rapidity with which the fungus multiplies, and gives an elaborate calculation of the number that might be found in a cell containing a deceased larva.

As might have been expected, Preuss's statement aroused considerable discussion at the meeting of German bee-keepers a short while after the publication of his paper.

Vogel (Bienen Zeitung, Nos. 21 and 22) expressed doubt as to whether *C. alvearis* was the real cause of foul brood or only a consequence of the disease, but on the whole agreed with Preuss.

Wiegand (Bienen Zeitung, Nos. 21 and 22) agreed with Preuss's theory, and in giving his experience said that the disease was introduced into his apiary through honey brought from a distance.

Pollman (Bienen Zeitung, Nos. 21 and 22) believed that the disease was introduced by feeding honey from Havannam, where, when extracting the honey, both brood and honeycomb were mashed up and the honey pressed out.

Doctor Leuckhart (Bienen Zeitung, Nos. 21 and 22) agreed with those who thought the disease due to a fungus, but discredited the supposition that it was the same as the fermentation fungus mentioned by Preuss, and rather thought it was related to the silkworm fungus and that most of the brood diseases ending in death were called "foul brood," while they were really something else. He believed that the fungus was present in the eggs of the queen when laid.

Geilen (Bienen Zeitung, Nos. 21 and 22) believed that the disease came from the putrefying remains of animal bodies upon which the bees alighted.

Muhlfeld (Bienen Zeitung, 1869, No. 3) again, in 1869, presented his former views and also those of Preuss and gave directions for maintaining the health of bees. He recommended the boiling of the honey and a use of carbolic acid in the strength of 1:100, or permanganate of potash 1:300, as disinfectants.

Lambrecht (Bienen Zeitung, 1870, No. 2) thought that foul brood was caused by fermentation of the bee bread.

Hallier (Bienen Zeitung, 1870, No. 2) considered it no specific disease, but thought it was probably produced by different fungi.

Cornallia (Bienen Zeitung, 1870, No. 5) proved contrary to the above and found a fungus which he thought developed foul brood. He called it *Cryptococcus alvearis* and used carbolic acid, potassium permag, and lime water as disinfectants.

Fisher (Bienen Zeitung, 1871, pp. 105–125) advanced a new foul-brood theory in 1871, which somewhat follows the view of Liebig regarding the silkworm disease and plant diseases. According to this theory, the predisposing cause was insufficient nourishment, especially short stores for winter and spring. Shortage of pollen supply was the next cause. Fisher tried to prove his views by the practical experience of bee keepers and explained that the first result of repeated and continued feeding was an increase in the production of bees; and a consequent disproportion between brood and brood feeders arose, which should be looked upon as another cause of foul brood. The disease, he said, might be lessened or exterminated by applying means to reduce the production of brood, as the removing of the queen and the area which the brood occupied. Foul brood is probably the cause of a quantitative dearth of nourishment and a consequent degeneration of the bees. The appearance of fungus growths was only a secondary matter.

Schonfeld (Bienen Zeitung, 1874, pp. 201 and 261) infected several hives with foul brood, and when it had fully developed he took a comb of the rotten brood to the Physiological Institute at Breslau and had it submitted to a microscopical examination by Doctors Cohn and Eidam (Bienen Zeitung, 1874, pp. 201

and 261). This examination showed that in every dead larva and in each foul brood cell, whether the contents were yet white and fluid or brown, tenacious, and ropy, there were to be found long oval bodies, which Preuss called "micrococci." Close to and among them, Cohn was the first to find, with the most powerful of the five microscopes that were used, a countless number of slender pale rods, joined together, and which he at once identified as bacteria of the genus *Bacillus*. The length of a single rod was about 6 micromillimeters, but many of them were two and three jointed, so that these foul brood bacteria microscopically resembled the anthrax bacteria, though of course they were different physiologically and in the manner in which they acted as ferments.

It is not surprising when we remember the state of bacteriological knowledge in 1870, that Preuss should have mistaken micrococci for the spores of a bacillus.

In 1885 the first investigation which merited close attention was published in the Journal of the Royal Microscopical Society, entitled "The Pathogenic History and History under Cultivation of a New Bacillus (*B. alvei*), the Cause of a Disease of the Hive Bee Hitherto Known as Foul Brood," by Frank R. Cheshire, F. R. M. S., F. L. S., and W. Watson Cheyne, M. B., F. R. C. S. One point is here to be especially noticed, there were two authors of this paper. The paper was divided into Part I, Pathogenic History, by Mr. Cheshire, and Part II, History Under Cultivation, by Mr. Cheyne, and with the latter part Mr. Cheshire had nothing whatever to do. Bee keepers are generally giving Mr. Cheshire the credit for this work, but it is clear that Mr. Cheyne, the man who did the bacteriological work, should be the one to get the credit. The description of the disease, contained in Part I, is as follows:

The nature of foul brood as a germ disease.—If a comb be removed from near the center of a healthy hive during the summer months its cells will normally be filled with eggs, larvæ, and pupæ in every stage of development. The eggs as left by the ovipositor of the queen or mother adhere commonly by the end to the base of the cells they occupy, and favored by the high temperature constantly maintained within the hive, the germinal vesicle at about three days matures into a larva ready for hatching. These eggs I have shown as liable to the disease even before they leave the body of the mother, but most careful microscopic examination is needful to make this apparent (and of which I shall speak presently more particularly). On the contrary, the larvæ, which are constantly fed by the workers, so change in appearance soon after infection that a practiced eye at once detects the presence of the disease. Whilst healthy their bodies are of a beautiful pearly whiteness, lying, at first floating, in the abundant pabulum the nurses are ever ready to supply. As they grow they curl themselves at the bottom of the cells until they become too strait for their occupants, which now advance to the head to be in readiness for the cocoon spinning, which follows upon the close of the eating stage. When the disease strikes the larvæ they move uneasily in their cells, and often then present the dorsal surface to its mouth, * * * so that mere posture is no insufficient evidence of an unhealthy condition. The color changes to yellow, passing on by degrees toward a pale brown, whilst the skin becomes flaccid and opaque; death soon occurs, when the body, now shrunken by evaporation, lies on the lower side of the cell, increasing in depth of tone, until in a few days nothing

> more than a nearly black scale remains. Should the larvæ, however, escape contamination until nearly the period of pupahood, they are sealed over in the normal way by a cover made of pollen-grains and wax. * * * and which is pervious to air. The cover furnishes a screen, on which part of the cocoon is soon after spread, but the inhabitant of the cell is marked out for death, and before very long the capping or sealing sinks and becomes concave, and in it punctures of an irregular character appear, * * * and this is a nearly conclusive sign of the diseased condition of the colony. The sense of smell is also appealed to, as a peculiar, very offensive, and extremely characteristic odor now escapes from the diseased combs. The bees, in addition, lose energy, but become unusually active in ventilating their hive by standing at the door, heads toward home, and flapping their wings persistently so that a strong outcurrent, and as a necessary consequence, a correspondingly indraught are set up. Should any attempt be made at removing a dead larva which has assumed a deep brown tint, its body tenaciously adhering to the cell wall will stretch out into long and thin strings like half-dried glue. The microscopist can easily explain this. The thin chitinous aerating sacs and tracheæ do not undergo decomposition at all easily, and these remaining, occasion the peculiarity referred to. * * * The disease is terribly infectious, and once started soon spreads from cell to cell and not unfrequently from stock to stock.

Mr. Cheshire was doubtless quite familiar with the disease of the brood and this description of the symptoms, we may assume, was not made from any one case, but from his entire experience. At that time two diseases of the brood were not recognized. We are justified in concluding that both diseases existed in England at that time, as they do now, and doubtless Mr. Cheshire had seen both without realizing that he was dealing with two distinct maladies. In this description he speaks of the disease as attacking brood at various times, for he says: "Should the larva, however, escape contamination until nearly the period of pupahood," etc. His description before that sentence applies as well to what we now call European foul brood as to American foul brood, while the latter description, especially where he speaks of the odor and ropiness, is undoubtedly drawn from experience with what we now call American foul brood. There is, at any rate, ground for the supposition that Mr. Cheshire was dealing with two diseases.

In the case of Mr. Cheyne, however, the case was entirely different. He was probably not familiar with the brood disease from practical experience. He also probably did all his work from one specimen, for he says: "On August 11, 1884, Mr. Cheshire brought to me a piece of comb containing larvæ affected with foul brood, with which I performed the following experiments." In describing this specimen he says: "These larvæ were dead, of a yellowish color, and almost liquid." This description certainly applies as well to European foul brood. Since the original description of *Bacillus alvei* is so important in this work, it may be well to quote entire Mr. Cheyne's part of this paper. This is practically unavailable to bee keepers, since it is contained in a journal to which few bee keepers can have access. It is as follows:

On August 11th, 1884, Mr. Cheshire brought to me a piece of comb containing larvæ affected with foul brood, with which I performed the following experiments: Selecting cells which were closed, but which Mr. Cheshire thought contained diseased larvæ, I brushed them over with a watery solution of bichloride of mercury (1:1000) to destroy the organisms on the outside. With several forceps, that had been heated and allowed to cool, the covering of the cell was picked off so as to display the diseased larvæ. These larvæ were dead, of a yellowish color, and almost liquid, and on examination afterwards their juices were found to contain numerous moving bacilli. By means of a heated platinum wire, tubes of meat infusion rendered solid by gelatin (10 per cent), or by Japanese isinglass, were inoculated from several of these larvæ and kept at a suitable temperature. Development of bacilli, microscopically similar to those seen in the juices of the larvæ, occurred. The characteristics of this development will be presently described. Further, in the tubes, kept at the body temperature, there was not only a development of bacilli but also of spores.

These bacilli, as seen in the larval juices, measure about $\frac{1}{7000}$ inch in length and $\frac{1}{20500}$ inch in breadth. They are rounded or slightly tapering at their ends and often have a clear space near one end. In the juices of the larvæ during life they apparently do not produce spores, although after death spores abound.

In the cultivation in the peptonized meat infusion, rendered solid by agar-agar. the bacilli vary considerably in size, their average length being $\frac{1}{7200}$ inch, some being as small as $\frac{1}{10000}$ inch and others as large as $\frac{1}{3000}$ inch. When they have attained the latter size, division of the rod seems to begin. They are always somewhat pointed at their ends. Their average breadth is $\frac{1}{30000}$ inch, varying from $\frac{1}{35000}$ to $\frac{1}{25000}$.

The spores are largish oval bodies, averaging in length $\frac{1}{12000}$ inch (varying from $\frac{1}{11100}$ to $\frac{1}{10200}$ inch), and in breadth $\frac{1}{23700}$ inch (varying from $\frac{1}{24000}$ to $\frac{1}{25000}$ inch).

In the agar-agar material the spores are generally arranged side by side in long rows, and in old cultivations only a few bacilli can be seen, some forming spores, some without any indication of spores. That these small bacilli can produce such large spores seems at the first glance at a microscopical specimen almost inconceivable, but I have been able to trace on the one hand the development of the spores in the rods, and on the other the sprouting of the spores into adult bacilli. This can be done in the following very simple manner:

Take a number of glass slides, each having a moderate-sized cell hollowed out in its middle; clean it and pass through a Bunsen flame several times to destroy any bacteria on its surface. With a brush apply a little vaseline around the depression, and then place the slide under a glass shade to keep it from the dust. Clean a number of cover glasses, purify them in the flame, and place them on a pure glass plate beneath another shade. With a fine, pure pipette put a small drop of sterilized cultivating fluid (meat infusion with peptone) on the center of each of these cover glasses; then with a fine platinum wire inoculate each of the drops with the spores, or with nonspore-bearing bacilli; rapidly invert them over the cell, press down the cover glass so as to diffuse the vaseline around its edge, and place the slides in an incubator kept at the temperature of the body. These slides are removed at different intervals of time, and as soon as each is taken out the cover glass is turned over and the drop of fluid rapidly dried. The specimen can then be stained, mounted in Canada balsam, and studied at leisure. This method seems to me to be much more satisfactory than the observation of the organisms swimming about in the drop of fluid, while the specimens can be kept permanently and compared with one another.

In order to study the growth of the spores, I used a cultivation on the agar-agar cultivating material which had been kept at the temperature of the body for fourteen days, and which consisted almost entirely of spores, though a few bacilli were present. As the result of several experiments, I have got a series of preparations which have been taken at various times (15 minutes, 30 minutes, 40 minutes, 1 hour, 1½ hours, 1 hour 50 minutes, 2 hours, 2 hours 20 minutes, 2 hours 50 minutes, 2 hours 55 minutes, 3 hours 20 minutes, 4 hours 20 minutes, 5 hours, 5 hours 35 minutes, 5 hours 40 minutes, and 7 hours 50 minutes), and the course of events is shown in Plate X.[a] The bacilli stain with various anilin dyes—best, I think, with methyl-violet; but the spores resemble the spores of other bacteria in not taking on the stain. The cover glasses on which the organisms are dried are passed three times through the gas flame and floated on the surface of a fairly strong watery solution of methyl-violet for one or two hours. They are then washed in water, and afterwards laid in weak acetic acid (1 per cent) till no more stain comes out. They are again washed in water, allowed to dry at the ordinary temperature, and mounted in Canada balsam. A spore-bearing cultivation shows the bacilli stained violet and the spores unstained, with the exception of their outline, which is of a faint violet color. In most cases no trace of the rod in which the spore was formed can be seen. The first change which is observed on cultivation is that in many cases the outline of the rod in which the spore was formed becomes faintly visible. This can be seen in 15 minutes, and is, I think, simply due to swelling by the fluid, as it is also evident to some extent in the case of spores soaked in water for the same length of time. In from half an hour to an hour it is evident that the bacilli which were present in the original material are beginning to multiply, and a considerable number of rods are now seen containing spores. It is evident that these spores are newly formed, as extremely few bacilli containing spores were seen in the original material, whereas in the preparations taken from a half hour to an hour a considerable number are present. That some of the rods, instead of growing by fission, at once proceed to form spores is probably to be explained in this way. When the cultivation was removed from the incubator, some bacilli were growing by fission, some were forming spores, and some had passed into a state ready to form spores. The first go on growing by fission, the last complete their spore-formation, which was arrested by removal from the warm temperature. That actively growing rods would not have formed spores so early is evidenced by the facts observed in the second series of observations on the formation of spores. The next thing that is observed is that several of the spores take on the stain, and are as intensely violet as the adult bacilli. The number of the spores which take on the stain in this way goes on increasing as time passes, till in about four hours almost all the spores stain violet. In three hours the first indication of sprouting of these spores becomes evident. The stained part of the spore loses its oval shape, becomes elongated, and is soon seen to burst through the spore-capsule at one part. It then presents the appearance of a short rod, with a pale envelope embracing one end. This rod gradually leaves the spore-capsule and then goes on multiplying as a full-grown bacillus. In specimens taken from four to five hours all stages of growth can be seen, and the remains of the ruptured spore-capsules are evident.

The bacilli appear to grow mainly by fission, but I have seen appearances which seem to me only explicable on the supposition that they also grow by sending out buds from one end. A bacillus may be seen with a small, somewhat conical stained point attached to one end, though separated by a marked division. This is certainly not the common mode of growth by fission, for there the rod seems to divide into two pretty equal halves, while here we have but a minute piece attached to one end.

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[a] Not reproduced here.

The mode of formation of spores may be traced in a similar manner to that described above in the case of the sprouting of the spores. It is, however, as a rule, necessary to leave the organisms to grow for a much longer time than in the former instance. I have not found development of spores as a rule before twenty-three hours, but this depends very much, apparently, on the amount of fluid that was present and the number of bacilli introduced at the time of inoculation. The first thing noticeable is that the rod begins to swell and becomes spindle shaped. The swelling, which generally affects the middle of the rod, may in some cases be most marked toward one end, increases in size. and the center of the swelling gradually ceases to take on the stain. The capsule of the spore is apparently also formed within the rod, and is not merely the outer part of the rod. In three or four hours the rod is seen to have almost or completely disappeared, leaving the spore lying free or within the faint outline of the original bacillus. It seems to me that the view that spore formation occurs when the food is getting exhausted is correct, for the time at which this appearance is found depends greatly on the drop placed on the cover glasses, and I have found in one experiment that in one specimen, after twenty-three hours, most of the rods were forming spores, while in another specimen where the drop was much larger there was no trace of spore formation after twenty-eight hours. I have here described the results of my earlier and rougher attempts to study the formation of spores. I have, however, now improved the method in the following way. As I have just now shown, the period at which spores are first seen seems to depend mainly on the amount of fluid used and the number of bacilli introduced, and as in the above method, both these factors vary in each case, one can not get a regular series of preparations showing the different stages at different times. In studying the sprouting of spores the amount of fluid and the number of spores does not matter, for if sufficient nutriment is present and a proper temperature is maintained the spores must sprout. and probably they always take about the same length of time. The difficulty of obtaining a series of specimens illustrating spore formation is easily obviated in the following manner. Take a pure flask containing a small quantity of sterilized infusion and inoculate it from a cultivation containing only bacilli. Place it in the incubator for two or three hours so that the bacilli may increase somewhat in number and diffuse themselves through the liquid. Thus the cultivating material contains bacilli pretty equally diffused through it, and if after shaking the flask drops of equal size are taken, each will probably contain about the same number of bacilli. The minutest quantity of fluid can easily be obtained by means of a syringe having a fine screw on its piston and a large nut revolving on this screw. The circumference of the nut being equally divided into a number of small segments, the same quantity of fluid can always be expelled from the syringe. By proceeding in this way equal-sized drops containing an equal number of bacilli can be used and a regular series of specimens obtained. I have found that using two-fifths of a minim containing one bacillus and keeping the specimen at 36° C., the earliest appearance of spore formation was evident in forty-one hours.

Leaving these matters, which are of great interest not only in regard to the *Bacillus alvei*, but to all spore-bearing bacteria, and which I have therefore dwelt on at length, we must pass on to the further consideration of this particular organism. The first point to be determined in investigating its relation to foul brood was whether this was a new bacillus, unknown except in connection with this disease of bees, or whether it was a more or less well-known form. To ascertain this point with regard to micro-organisms the microscope is of little use; recourse must be had to the study of their life history, more especially to their peculiarities of growth on different soils. Of all the materials employed as cultivating media, Koch's gelatinized meat infusion is the most useful for purposes of diagnosis. This is composed of an infusion of meat containing 1 to 3 per cent of pepton, 10 per cent gelatin, made neutral by carbonate of soda, and thoroughly sterilized. This material was first introduced with the view of having a highly nutritive solid and at the same time transparent medium on which to carry on pure cultivations, but it was soon found that owing to the remarkably diverse ways in which different micro-organisms grew in it, it could be used as a means of diagnosis of the kind of organism, a means more certain than any other which we at present possess. For purposes of diagnosis, as well as with the view of carrying on pure cultivations, this material is used in three ways. While the material is still fluid a small portion is poured into a number of pure tubes plugged with cotton wool, sterilized, and allowed to solidify. A fine platinum wire, heated in a flame and allowed to cool, is dipped into the material containing the bacterium in question, and then, after the removal of the cotton-wool plug, is rapidly plunged down through the gelatin to the bottom of the tube and then withdrawn. The plug is reinserted and the tube kept at a temperature suitable for the development of most forms of bacteria, but not high enough to melt the gelatin. If growth takes place at this temperature it occurs either on the surface around the point of entrance of the needle, or along the needle track, or in both places, and the appearance of the growth varies remarkably, according to the different species of micro-organisms studied. The second way is to liquefy and pour out a little of the gelatinized material on microscopic slides or on larger plates of glass which have been sterilized by heat. These plates are placed in glass vessels containing moist blotting paper to prevent drying of the gelatin and to protect them from the dust. After the gelatin has solidified the purified platinum needle charged with the bacteria is drawn rapidly over the surface of the gelatin. Bacteria are sown along the track, grow there, and the whole can be placed under a microscope and the characteristics of the growth studied with a low power. In the third mode a tube of the gelatin mixture is inoculated with a very minute quantity of the bacteria. The tube is then placed in water at the body temperature to melt the gelatin. When the material is melted, it is thoroughly shaken up to diffuse the bacteria through it and, while still liquid, is poured out on sterilized glass plates kept in a moist chamber, as in the former case. Solidification very soon occurs, and the bacteria being caught at various parts of the gelatin grow there in the form of groups or colonies, which can be observed under the low power of the microscope. I shall now describe the characteristics of the *Bacillus alvei* when cultivated in these three modes.

(*a*) *Test-tube cultivations.*—If an infected needle be plunged into a tube of gelatinized meat infusion in the manner described above, growth occurs both on the surface and along the needle track. On the surface the bacilli shoot out in all directions from the point of entrance of the needle, forming a delicate ramifying growth on the top of the gelatin; the characteristics of this growth will be presently described under *b*. Along the track whitish irregular shaped masses appear, which slowly increase in size and run together. In a few days processes are seen to shoot out from these masses, which may extend through the gelatin for long distances from the track, being thickened at various parts and clubbed at the ends. These processes do not appear to join one another at their ends. A very beautiful and characteristic appearance is got where very few bacilli are introduced with the needle and where, therefore, at various parts of the track, more especially at the lower part, individual bacilli or groups of bacilli are planted at a considerable distance from each other. In a few days minute round whitish specks become visible to the naked eye. These increase in size till in about ten days shoots begin to appear. These radiate from the central mass in all directions and become nodular at various parts, as described above. When such a cultivation is old, the white branches disappear, and only little whitish collections of bacilli are seen at various parts. On examining such a tube with the pocket lens, however, numerous watery-looking tracts are seen running through the gelatin from the central mass to the whitish collections. The gelatin at the upper part of the track generally evaporates, to some extent giving rise to the air-bubble appearance so characteristic of the cholear bacillus. These are the appearances seen where the material contains gelatin in the proportion of 10 per cent. Where less gelatin is present, the naked eye appearances, while possessing the same characteristics, are somewhat different. The shoots are much more numerous and appear much more rapidly, giving rise to a haziness around the middle track, which with the pocket lens is seen to consist of numerous delicate branches clubbed at the ends, as in the former case. I think the amount of pepton present also makes a difference in the appearance, though of this point I am not yet absolutely certain. The most characteristic growth is, however, obtained when the material contains 3 per cent pepton as well as 10 per cent gelatin, the shoots being then less numerous and much coarser. And I can easily understand that this would be the case, for the bacilli would have a large supply of nutriment in their immediate vicinity without the necessity of having, so to speak, to spread out through the gelatin in search of food as may be the case where no pepton, or only a small amount, is present. This appearance is quite characteristic of this bacillus and is not seen in the cultivation of any other organism that I know of. The bacilli of anthrax and of mouse septicæmia also spread out from the needle track, but the appearance of their cultivation is quite different. In anthrax delicate threads, not clubbed, shoot out from the track, soon anastomosing with other threads and forming a delicate network throughout the gelatin. In mouse septicæmia the appearance is that of a delicate cloudiness spreading through the gelatin. These foul-brood bacilli, growing in this material, render it liquid after a time, the liquefaction beginning at the surface and only spreading slowly downwards, but ultimately the whole tube becomes liquid. After two or three weeks' growth the appearance presented by the tube is that of a layer of liquid at the upper part, and the growth along the needle track with the other appearances described at the lower part. The liquid portion is clear, except at the bottom of the liquid, where there is a loose white flocculent deposit of bacilli, and on the surface there may be a very thin scum. The liquid becomes yellowish in colour after a time and gives off an odor of stale but not ammoniacal urine, or what may be better described as a shrimpy smell. This yellowish colour and the peculiar odour have been found by Mr. Cheshire to be distinctive of the diseased larvæ.

(*b*) If gelatin be poured out on a plate, allowed to solidify, and then stroked with an infected needle, we learn the explanation of the appearances seen in the test-tube cultivations. The bacilli at first grow along the needle track, but very soon they are seen to be collecting at parts forming pointed processes. From the processes the bacilli grow out into the gelatin, often a single series of rods in Indian file, or two or three rods side by side. These processes are not quite straight, but tend to curve, and at a little distance from the track they grow round so as to form a circle. From this circle, which may be formed of single bacilli, the process continues forming a fresh circle farther on. The bacilli in the circle increase in number till ultimately it becomes completely filled up, and we have a nodule consisting of bacilli in the course of the shoot. These shoots may also join one another, forming a curved anastomosis, and the gelatin in the immediate vicinity of the bacilli becoming liquid, a series of channels are formed in the gelatin containing fluid in which the bacilli swim backwards and forwards. Later on parts of these channels become apparently deserted by the bacilli, so that the circles look to the naked eye as if they were detached from the main track, but with a low power of the microscope the empty channels can be traced.

It is impossible to give a proper idea of the appearance of the growth. The forms assumed are the most beautiful shapes I have ever seen, but they are very numerous, always, however, retaining the tendency to form curves and circles; thus we have the explanation of the appearances previously described in the test-tube cultivations.

(*c*) The appearances of the colonies on plates on which the mixture of bacilli and gelatinized infusion has been poured out is also very characteristic. The earliest appearance of colonies is a small oval or round group of bacilli. This group is not homogeneous in appearance under a low power of the microscope, but lines indicating the bacilli are seen in it. It very soon becomes pear-shaped, and from the sharp end of the pear processes begin to pass out into the gelatin as before described.

These bacilli do not grow below 16° C. The best growth in gelatin is obtained at a temperature of about 20° C. They grow most rapidly in cultivating materials kept at the body temperature. Very few spores are formed at the lower temperatures, but they appear rapidly and in large numbers at the body temperature. I have several times observed bacilli containing spores swimming about freely. The reaction of the medium is not of any great importance, but a neutral medium is apparently the best. The bacilli swim freely in fluids with a slow oscillating movement.

They grow rapidly at the body temperature in meat infusion with pepton and rendered solid by agar-agar, but the appearance of their growth is not nearly so characteristic as in gelatin. This, indeed, is the case with most bacteria, so that agar-agar preparations, though very useful for carrying on pure cultivations at the temperature of the body, are of little value for diagnostic purposes. They grow most rapidly on the surface of the agar-agar, forming a whitish layer, but the shoots described above in the case of gelatin do not occur, or only very imperfectly, in agar-agar. Here the bacilli arrange themselves apparently side by side, and, producing spores in this position, we have as a result, after a few days' cultivation, long rows of spores lying side by side with here and there an adult bacillus.

On potatoes they grow slowly, forming a dryish yellow layer on the surface. They grow very slowly indeed at the lower temperature. In order to get good growth it is necessary to keep the potato at the body temperature.

In milk they grow well at the body temperature, and in a few days cease coagulation of the milk, which also assumes a yellowish colour and gives off the odour previously described. The coagulum is not firm, like that caused by the *Bacterium lactis*, but is like a tremulous jelly, and may remain for a considerable time without the separation of any fluid, but ultimately it becomes liquid, and after some months assumes the appearance of a dirty, brownish-yellow, glairy fluid. It is very slightly, if indeed at all, acid.

They grow extremely slowly in coagulated blood serum, though kept at the body temperature, and there form very long filaments with comparatively few spores.

In meat infusion kept at the temperature of the body they grow readily, causing muddiness, and after a few days a slight but not tenacious scum. The same peculiar odor is also developed here, more especially if the infusion contains a considerable amount of peptone. I do not think that there is any change in the reaction of the fluid; I generally make the infusions faintly alkaline, and after the growth of this organism in it it is faintly alkaline.

These characteristics show that this is a new bacillus, and one which, so far as my knowledge and experience goes, is only found in foul brood. The constant presence in large numbers of a characteristic organism in a disease and its absence elsewhere must, according to our accumulating experience, afford a strong presumption that the organism is the cause of the disease. In the case of foul brood this matter has been completely proved by the following experiments, the details of which will be found in Mr. Cheshire's part of this paper. With a cultivation in milk he sprayed a comb containing a healthy brood, allowing the spray to act only on a particular part of the comb. This part and no other became affected with foul brood. He has also succeeded in infecting adult bees by feeding them with material containing these cultivated bacilli.

I have also had the opportunity of watching the effect of feeding flies with material containing spores and bacilli. I was one day testing some milk in which these bacilli were growing; a large blue-bottle fly settled on it and commenced to eat. I at once put a large glass funnel over the insect, leaving plenty of air. When I came to the laboratory twenty-four hours later, the fly was in the sitting posture on the table and was dead. Its juices were full of these bacilli, as shown by microscopical examination and by cultivation.

Other animals which I have tested are more or less refractory to this bacillus. I have kept cockroaches for days in a box in which was milk containing these bacilli mixed up with sugar. I have also kept them in a box containing a piece of paper which had been thoroughly smeared with the spores. None of them died, but I can not be certain that in either case they ate any of the material, for I never saw them even near it.

I inoculated two mice and one rabbit with a spore-bearing cultivation without effect.

I injected half a syringeful of a spore-bearing cultivation into the dorsal subcutaneous tissue of each of two mice. One of these died in twenty-three hours, the other seemed unaffected, but in the second case I doubt whether the full quantity was introduced. In the case of the mouse which died, the seat of injection and the neighbouring cellular tissue was found to be very œdematous, but no microscopic changes were apparent in the internal organs. Numerous bacilli were found in the œdematous fluid, as also a number of spores which had not been sprouted, and there were also a few bacilli in the blood taken from the heart. This was proved, of course, by cultivation as well as by microscopical examination. On examining sections of the various organs no morbid changes were found, and only very few bacilli were seen in the blood vessels.

At the same time that I injected the mice I injected a syringeful of the same cultivation subcutaneously into a guinea pig. This animal died six days later with extensive necrosis of the muscular tissue and skin and cheesy-looking patches distributed through it. There was no true pus. On making sections of the necrosed tissue numerous bacilli, apparently *Bacillus alvei*, were seen.

but there were other bacteria and also micrococci, as of course would be the case on account of the death of the skin. No micro-organisms were seen in the internal organs. It thus remains questionable whether the necrosis was due to the *Bacillus alvei* or not, more especially as I have since injected three guinea pigs subcutaneously with spore-bearing cultivations, but without effect. I must reserve the action of these bacilli on the higher animals for further investigation, as well as several other points of interest in regard to this organism to which I have not here alluded.

I venture to think that when all the evidence brought forward by Mr. Cheshire and myself is carefully weighed no doubt can be entertained that this bacillus is new to science and is the cause of foul brood. Many questions of course still remain open, requiring further investigation into the life history of the disease.

The next investigator to take up a bacteriological treatment of bee diseases was Prof. J. J. Mackenzie, bacteriologist of the provincial board of health of Ontario. The results of this work were published in the Ontario Agricultural College Report for 1892, pages 267–273. At the request of the Bee Keepers' Union of Canada certain things were taken up which had a very practical bearing on the question of eradicating the prevalent disease.

Professor Mackenzie knew of but one disease, probably, and having in hand the work of Cheshire and Cheyne, assumed that the disease found in Canada is the same as that described by Cheyne. This is a natural mistake after the confusion in the diagnosis by Cheshire. It was not the object of this investigation to demonstrate what organism produces the diseased condition, but, assuming that *Bacillus alvei* causes the trouble, to determine what resistance to heat the organism has.

No adequate description, such as would allow us to make any comparisons with *Bacillus alvei*, is included in Professor Mackenzie's paper. We do know, however, or at least have every reason to believe, that European foul brood was not found in Canada at that time and is not prevalent there now. I have been informed personally by Mr. William McEvoy, the veteran inspector of Ontario, that the disease which we now designate as American foul brood is the prevailing disease in Canada. It seems reasonable to suppose, therefore, that the samples taken to Professor Mackenzie by Mr. Holtermann and others did not contain any *Bacillus alvei.*

Professor Mackenzie does not indicate in his paper that he had any difficulty in getting the organism with which he worked to grow on ordinary media. *Bacillus larvæ*, which is present in American foul brood, does not grow in such media, however, so there is but one conclusion to be reached, and that is that he was dealing with some nonpathogenic form and not with *Bacillus larvæ*. Since the bacillus described by Doctor White as *Bacillus A* is found on combs, both diseased and healthy, and somewhat resembles *Bacillus alvei*, it may be that this is what Professor Mackenzie had.

This paper has probably come to the notice of but few bee keepers in the United States, because the report of the agricultural college is not widely distributed. To make it available for comparison, therefore, it is included here.

THE FOUL BROOD BACILLUS (B. ALVEI); ITS VITALITY AND DEVELOPMENT.

[From Ontario Agricultural College Report for 1892, pp. 267–273.]

Mr. J. J. Mackenzie, B. A., bacteriologist of the provincial board of health of Ontario, read the following paper:

GENTLEMEN: At the request of your secretary, Mr. Holtermann, I undertook for your union some investigations on the subject of foul brood, the results of which I propose giving you in this paper. Although it is almost a year now since I undertook this work under the auspices of the Agricultural and Experimental Union, it is by no means exhausted, and there are many points which require to be further elucidated, which I have not had time as yet to touch on, owing to the fact that investigations on foul brood had to be carried on simultaneously with my regular laboratory work. These points I hope to work at next summer, and reserve the privilege of reporting again to your union on the results of further investigation.

The subject of foul brood is an old one to apiarists and an intensely interesting one to Canadian bee keepers, but in reading over the bee journals one can not help being struck with the great want of unanimity amongst bee men as to the disease, how it should be treated, how it is spread, and on many other points. Some would have us believe that the disease arises de novo whenever insanitary conditions prevail; others claim that there is a specific infection and where the disease arises it must have originated from previously existing disease; some claim that the honey is the only method of transmittal; others that it is not, and so on. On every point there seems to be plenty of arguments pro and con.

I have attempted in my work to take hold of some of these controverted points from a bacteriological standpoint in order to aid in coming to some definite conclusion. Some of these points I should consider settled from the results of previous investigation; but as many bee men do not seem prepared to accept this, my work will have value as confirming what has already been done.

Before an association which includes many practical bee keepers it would be superfluous to enter upon a minute account of the clinical features of the disease. Most of you know them better than I do. I certainly would not be prepared to "spot" foul brood in an apiary, although I certainly think I can under the microscope. The infectious character of the disease has been generally accepted for many years, but not until Cheshire and Watson Cheyne worked it out scientifically was it definitely proved. They isolated a bacillus (*Bacillus alvei*) which they found in the diseased brood and which they cultivated on nutrient media for many generations, finally reinfecting perfectly healthy brood from these pure cultures. This evidence to a bacteriologist is absolutely conclusive that *Bacillus alvei* is the specific cause of foul brood. Consequently, when I began my investigations on some samples of diseased brood which were sent me through Mr. Holtermann, I looked at once for *Bacillus alvei.* Microscopically and by means of bacteriological methods I had no difficulty in isolating a bacillus which corresponds in all points to *Bacillus alvei.* It is a bacillus similar to that of Cheshire's in size, produces spores which are somewhat thicker, giving the bacillus a clubbed appearance. On agar jelly it grows rapidly so as to cover the whole surface. In gelatin its growth is very peculiar, shooting out from the infected point in all directions. On potatoes it produces a yellow growth. All these characters show conclusively that it is identical with *Bacillus alvei*. There seems no doubt, therefore, that the foul brood which we have in Ontario is the same disease and produced by the same bacillus as in other places.

Many prominent bee keepers, both here and in the States, however, maintain that wherever unsanitary conditions are allowed to prevail, wherever chilled brood is allowed to putrefy, or decapitated drones are left to decay in the hive foul brood may arise de novo. This is not a new theory, either in bee keeping or in medicine, but unfortunately it is a theory which is not supported by the results of investigation. Diphtheria naturally will develop more readily if unsanitary conditions are present, but it certainly will not develop if the *Bacillus diphtheriæ* is absent. The same is true of other diseases, and consequently when we come to consider such a decidedly infectious disease as foul brood and learn the facts about it which such men as Cheshire have told us we naturally come to the same conclusion. If I were to maintain that a Carniolan queen might lay an egg which would develop into a humble bee, bee men would be inclined to think that not only my bee knowledge, but also my scientific knowledge, was at fault; but yet in all the bee journals I find many prominent bee keepers maintaining that an ordinary microbe which produces putrefaction may become metamorphosed into the specific cause of foul brood. It it is easy enough, however, to combat such an opinion upon a priori grounds, but not quite so easy to offer convincing proof.

In order to do this I thought it worth while to try some experiments. With this end in view I obtained some comb containing chilled brood and endeavored to isolate *Bacillus alvei* from it, but without success.

There were plenty of other bacteria, but none which presented the well-marked morphological characters peculiar to *Bacillus alvei*. Again I had sent to the laboratory a piece of perfectly healthy comb. I killed the brood by chilling. Then I infected some of the cells from a pure culture of *Bacillus alvei*. I allowed all the chilled brood to putrefy in a moist chamber for two weeks, at the end of which time I obtained *Bacillus alvei* again from the cells which had been artificially infected, but could find no traces of it in the other cells. I left this comb in a moist chamber for several months and again examined, but with the same results. In the cells in which *Bacillus alvei* had been placed it was still to be found; in the others it was not present.

It seems to me that an experiment such as the above conclusively shows that there is a distinct difference between foul brood and ordinary putrefaction.

In considering the subject of the vitality of *Bacillus alvei* the first question which naturally arises is its power to resist heat. We know that bacilli which produce spores and those which do not stand in entirely different positions in this regard. The sporeless bacillus is destroyed at a much lower temperature than one which contains spores. Consequently in considering the question of the vitality of *Bacillus alvei*, which produces spores very quickly and easily, we may confine our attention entirely to the vitality of the spore.

This is of special interest, as the question has been repeatedly raised whether it is dangerous to use comb foundation made from foul-broody wax. Does the temperature to which the wax is raised in the manufacture of comb foundation sufficiently destroy the vitality of the spore? Can the spore germinate and infect the brood when once inclosed in the wax?

These questions have been raised by many careful thinkers among bee men, and certainly deserve attention. The second point ought to be considered first, since if surrounding a spore with a film of wax prevents its germination, we need pay no further attention to the question of heat. The crucial test of this would naturally be, supply a healthy colony with comb foundation known to contain the spores and observe the result. This I had hoped to try with the assistance of your secretary, but other work came up which interfered with the carrying out of this experiment and consequently it had to be postponed until next year. However, I was able to perform one experiment which throws some light on the subject. Mr. Holtermann, the secretary of your union, sent me several pounds of very fine wax, such as is used for the manufacture of comb foundation. I cultivated the *Bacillus alvei* upon agar jelly until I had a large quantity of the bacilli containing spores; this was carefully scraped off the jelly and dried first in the air and then over sulphuric acid. The resulting grayish mass was pulverized with a sterilized pestle and mortar, and finally mixed thoroughly with the melted wax kept at a temperature sufficiently low to prevent the immediate destruction of the spores by heat. By this means an enormous number of spores were introduced into the wax. After stirring the wax for some time in order to insure a proper mixing it was allowed to cool. This, as you all know, takes some time when dealing with a considerable quantity. During the cooling I was careful not to disturb the wax.

After it had solidified I set out to discover if I could again obtain my bacillus from the infected wax. If it would germinate in the nutrient media, it certainly would in the bees, and that point was to a certain extent settled. Now I obtained the following results:

From the upper layers of the infected wax I was unable to obtain cultures of the *Bacillus alvei*, either by melting the wax in the nutrient jellies or by allowing particles of the unmelted wax to fall on the surface of these jellies.

From the under layers, however, the results were different; particles of wax placed on nutrient agar in an oven kept at 98° F. became surrounded in twenty-four hours with a luxuriant growth of *Bacillus alvei*. When the wax was melted into the agar or into beef tea, I also obtained the bacillus, consequently it looks as if the mere fact of enveloping the spores with a film of wax was not sufficient to prevent germination. I confess I can not understand how a spore could germinate when surrounded with a film of wax. Spores in germinating require moisture, and if a spore is completely embedded in wax, it can not obtain sufficient moisture to germinate; I would rather believe, therefore, that in this particular experiment the spores had not each an envelope of wax, but that many of them were partially free from wax. Now, if this was the case in my experiment, where I endeavored to make the incorporation of the spores in the wax as thorough as possible, I certainly think it may frequently be the case when foul-broody wax is used and no particular precaution taken. That even when spores are thoroughly surrounded by wax they may not be freed occasionally by the workers is a point which requires further elucidation and upon which I intend to try some experiments next year.

In looking through the bee journals, however, I find it everywhere maintained by foundation makers that they never knew of a case of foul brood originating from foul-broody wax; and I have yet to discover a well authenticated case where this has occurred. What explanation can we offer of this widespread opinion?

I explained to you above that I was unable to cultivate *Bacillus alvei* from the upper layer of the infected wax. Your secretary also sent me a small specimen of wax which he stated he knew to be from foul-broody comb. This I examined repeatedly for foul brood, but was able to obtain it only once. I think we must look to the physical conditions for an explanation of the freedom from infection through comb foundation. The difference in the specific gravity of the bacteria and of melted wax is so great that throughout the process of manufacture the bacteria tend to fall to the bottom. The first refining of the wax must, of course, remove the greater quantity, and the vast majority of the remainder will settle to the bottom during the process of foundation manufacture. But that the simple process of mixing the infected material with the melted wax is not sufficient to prevent germination I think is shown by the results quoted above, where simple fragments of infected wax when placed on agar jelly gave rise to a culture of *Bacillus alvei.*

This question I hope to touch on again after I have had an opportunity of supplying healthy bees with foundation made from infected wax.

The other question is whether the temperature to which wax is raised during foundation making is sufficiently high to destroy the spores of foul brood. In order to decide this question there are several points to be noted. The first is the character of the heat. We know that moist heat will destroy bacteria and their spores much more quickly than dry heat, and Mr. Corneil, of Lindsay, has raised this point several times, claiming that the heat to which the bacteria are exposed in melting wax is not moist heat but dry heat, consequently we must heat to a high temperature and for a long time in order to destroy the spores. The point is undoubtedly well taken, and can only be settled by direct experiment. In order to determine the temperature at which the spores are destroyed in melted wax, I used a method that was first described by Koch. Sterilized silk threads were saturated with a beef-tea culture of *Bacillus alvei* in which there were large numbers of spores. These threads were then allowed to dry and in the dry state were preserved. These dried threads were introduced into the melted wax and allowed to remain in it for a definite time at a fixed temperature. At the end of that time the thread was introduced into the melted agar or into beef tea heated to the melting point of wax, and thoroughly shaken, so as to separate the wax as much as possible from the threads; then the culture medium was rapidly cooled, and the tubes placed in the ordinary cultivating oven kept at 98° F. If I obtained a growth of bacilli, I concluded that the threads had not been sufficiently heated in the wax; if I did not, I concluded that they had been sufficiently heated. The following are my results:

At 212° F. (100° C.):
- For one-quarter of an hour: Growth.
- For one-half an hour: Growth.
- For one hour: Growth.
- For one hour and a half: Growth.
- For two hours: Growth.
- For two hours and a half: No growth.

At 194° F. (90° C.):
- For one-half hour: Growth.
- For one hour: Growth.
- For two hours: Growth.
- For three hours: No growth.
- For four hours: No Growth.

On the other hand, a temperature of 122° F. (50° C.) did not destroy the spores in twenty-four hours.

I have repeated these experiments several times with the same results, so that I would conclude that to destroy the foul brood in wax it is necessary to heat to a temperature of at least 194° F. for at least three hours. Now the question arises, does this take place during the process of manufacture of comb founda[illegible] In order to get as much data as possible on the subject I wrote to [illegible] of Michigan Agricultural College, as he had kindly offered me any assistance in his power. He applied to two prominent foundation makers for information. From their replies it is apparent that, for a short time at any rate, during the refining and purifying of the wax it reaches a temperature quite at or near 212° F. During sheeting, however, it apparently does not reach a temperature much above the melting point, say 175° F. They both seemed to agree that steam heat for too long a time injures the quality of the wax.

In the American Bee Journal, 1891, page 470, we find some statements on the subject in a reply by two prominent foundation makers to an article by Mr. Cornell upon the dangers of infected comb foundation. One of them, Mr. Dadant, states that in refining it is heated for some time at 212° F. and is kept liquid for twenty-four hours. The other, Mr. M. H. Hunt, states that it is kept at the boiling point for six or seven hours. If these are the actual temperatures reached during foundation making, I am inclined to think there is little danger from foul brood in that direction.

I thought it possible that the whole question could be settled by introducing a certain amount of some disinfectant—say beta naphthol—into the melted wax, but my results have not been satisfactory. Apparently even the introduction of 1 per cent beta naphthol into wax did not hasten materially the destruction of the spores. I was able to demonstrate the presence of living spores in wax containing 1 per cent beta naphthol and heated for two hours to 194° F.

From all these facts, and taking into consideration also the physical fact of the settling of the bacilli to the bottom, I should think that with reasonable care in the preparation of comb foundation the dangers of infection from this source would be slight. But that the spores may germinate after being mixed with the wax, I think I have shown.

Why the spores of the *Bacillus alvei* are killed so quickly in the melted wax I am not able to explain, but it may be due to the fact that the wax itself when heated to such a temperature has an antiseptic value. That the spores resist other antiseptics as strongly as do the spores of anthrax I have proved by testing.

Cheshire and others recommend a solution of 2 per cent carbolic acid for disinfecting the hive after removing infected comb, but on actual experiment with the infected silk threads I have found that 2 per cent carbolic acid did not kill the spores in six days. These results are similar to those obtained by Koch for the spores of anthrax, and show that 2 per cent carbolic acid can not be relied on to destroy the spores. However, the question of the value of antiseptics I will take up more in detail later on in this paper.

I would like to say a word or two now on the methods of treating the disease. There are practically two methods: first, the starvation method; second, the method of medicated sirup. Mr. McEvoy's method of treatment, it seems to me, is practically a modification of the starvation method. The first method is widely used both here and in the United States, whilst in England and Europe generally the second method is adhered to.

Considering the vitality of the spores of foul brood, it would seem at first sight useless to try any process which did not recognize as its foundation the destruction of the germ. I find, however, that many prominent bee keepers who have had practical experience with the method of starvation, or Mr. McEvoy's method, accept it as successful. I have not had an opportunity to examine colonies which have been cured in this manner, and so can not say that the bacilli have disappeared. I hope next summer to test this question more fully. We may, however, examine into the rationale of the method. In conversation with Mr. Cornell, of Lindsay, he mad[illegible]estion which may be quite familiar to you all, but which seems to me

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tion. That suggestion was that either starvation or comb building carried the infected nurses past the period at which they act as nurses and gave them a chance to rid their intestines of the germ. If this is combined with a removal to absolutely clean hives, with new foundation, it may succeed, but I must say that absolute cleanliness in this respect must be insisted on. As I said above, I have not had any opportunity of investigating the results of these methods practically, and so can not speak with certainty.

The fact of the presence of the bacilli in the workers and in the queen bears, to a certain extent, upon this question. Cheshire and others make the statement that the bacilli are found in the intestines of the workers and in the ovaries of the queens. My own experience confirms this. I have found them repeatedly in the workers, and in five queens from infected hives I succeeded in obtaining the bacillus from the ovaries of three. That they are not always present in the ovaries of the queens from diseased colonies is certain; their presence there is apparently accidental. For instance, in the case of one last year's queens in a hive rather badly diseased I was unable to find the bacillus, whilst in a six weeks' queen from a hive in which there were only a few diseased cells I succeeded in finding it.

Cheshire's statement that he found a bacillus in an egg of an infected queen seems to me to require confirmation. I have not been able to find the eggs infected myself, but it is a question which would require very long and careful investigation before one could be able to deny or confirm such a statement.

In the second method of treatment by medication I do not think that an absolute destruction of the spores takes place, any more than in the starvation method. As I have shown above, 2 per cent carbolic acid was not sufficiently strong to destroy the spores, consequently it is not likely that 0.2 per cent (1 part in 500) would be strong enough. I tried 0.2 per cent, but found it quite unsuccessful. Its action then must have another explanation. To test this I made up a sterilized beef broth containing 1 per 500 of carbolic acid, and in it placed my infected silk threads. I found that there was no indication of growth. These threads were then taken out and placed in ordinary sterilized beef broth, and I obtained a luxuriant growth, i. e., the 0.2 per cent carbolic acid in the culture fluid, although it did not destroy the spores, prevented their germination. That, then, is the explanation of the value of carbolated sirup in the treatment of foul brood, it prevents the germination of the spores. The bee journals contain numerous examples of cases where carbolated sirup produced an improvement, but as soon as it was stopped there was a relapse. It is evident that here again, as in the starvation process, there must be combined an extremely thorough cleaning up, so that the best possible results may be obtained from the treatment. Medicated sirup does not destroy the spores, it simply prevents their development and gives the bees a chance to rid themselves of the infection, and in that respect I certainly think resembles the starvation process. Its advantage over that is that it can be carried on for a longer time.

In the course of these experiments I tried another substance which has been much used since Lortet's work on the subject, viz, beta naphthol. I do not think myself, from recent work on this substance, that beta naphthol should be ranked very high as an antiseptic, mainly on account of its insolubility in water. I found, however, that a beef broth containing 1 per 1,000 beta naphthol would not allow spores of *Bacillus alvei* to germinate, and consequently had an equal value with 1 per 500 of carbolic acid. It has an advantage over carbolic acid on account of the disagreeable taste of the latter, and I think would be more acceptable to the bees.

Salicylic acid in sirup has apparently the same effect, but I would not recommend the addition of borax, as Behring has shown that borax lowers considerably the antiseptic value of salicylic acid.

I tested also formic acid in the same way, but my results so far have not been satisfactory, owing to the uncertain strength of my sample of formic acid. I prefer to reserve a report upon it and other substances which I wish to try until later.

Mercuric chloride I have not tested, as I do not think it wise to use it around the hive. The idea of using a 1 per 1,000 solution to spray the diseased combs, as suggested sometimes, is, I think, absurd, and would be a rather serious operation for any living brood.

You will see that I consider all these methods of treatment do not in themselves necessarily presuppose the destruction of the spores, but depend upon the fact that for a longer or shorter period the spores are prevented from germinating, and in this period they are eliminated from the infected bees. Whether the vitality of the bees themselves has an effect upon the elimination or destruction of the spores is a point which would be extremely interesting, but one on which at present we have no definite information. From the results of bacteriological work on other diseases we know that the animal body is engaged in a constant warfare with the disease germs which may be introduced, and this also may be the case in foul brood. Much more extended investigations, however, would be necessary to prove this. It is much safer for apiarists to accept the possibility of a recurrence of the disease after a course of treatment, owing to the lodgment somewhere of some of the spores of *Bacillus alvei*, and by care and cleanliness remove this possibility. To do this the hives and frames in which a foul broody colony has lived must be sterilized, and this may be done in various ways. For the sterilization of material by disinfectants there was a tendency formerly among bacteriologists to run to such disinfectants as corrosive sublimate, carbolic acid, etc., but later work has shown that there are a number of common chemicals which will act just as well, or perhaps better. Corrosive sublimate has lost much of its reputation as a disinfectant within the last few years, and carbolic has been shown to be not nearly so powerful as at first supposed.

For cleaning hives and frames which are suspected to contain the spores of foul brood a hot 10 per cent solution of soft soap is perhaps as effectual as any that can be recommended. A good strong solution of washing soda, when hot, is also very active, destroying the spores in a few minutes. Both these are certainly better than 5 per cent carbolic for disinfecting the hives and frames, as their cleansing properties are so much better than it, and Behring has shown that 5 per cent carbolic requires at least three hours at blood heat to destroy the spores of anthrax. In case the soap or the washing soda is used, however, it must be used as hot as possible. Of course anything which is of no value should be burned.

I trust that in this paper I have thrown a little light upon some of the facts in connection with the disease of foul brood, but, as I stated in the beginning, I reserve the privilege of submitting to you at a future meeting the results of next summer's work.

Before closing I desire to express my thanks to your able secretary, Mr. Holtermann, for the assistance which he has given me, and also to Mr. Corneil, of Lindsay, for advice and for the use of volumes of all the principal bee journals, which he has supplied me with; also to Mr. Larrabee, of Michigan Agricultural College, in connection with the subject of comb foundation.

The next investigation to be considered is that by Prof. F. C. Harrison, professor of bacteriology of the Ontario Agricultural College. Previous to this Dr. William R. Howard published a paper on the subject, but this can be discussed better at a later time. In the paper by Professor Harrison, previously mentioned, the author gives a detailed description of the bacillus with which he worked. The description is as follows:

THE ORGANISM.

Bacillus alvei, Cheshire and W. Cheyne, 1885, from the larvæ of bees suffering from the disease known as foul brood, la loque (Fr.), and faul brut (Ger.).

Morphological characteristics.—In form the organism is a slender bacillus, with ends slightly pointed and rounded. "In the larval juices it is about $\frac{1}{7000}$ of an inch in length and $\frac{1}{20500}$ in breadth. On agar the bacilli vary considerably in size, averaging $\frac{1}{7260}$ inch, some small as $\frac{1}{10000}$ inch, and others as large as $\frac{1}{5000}$ inch. When they have attained the latter size, division of the rod seems to begin. They are always somewhat pointed at their ends. Their average breadth is $\frac{1}{30000}$ inch, ranging from $\frac{1}{35000}$ to $\frac{1}{25000}$ inch (Cheshire and W. Cheyne). Klamann (Bienenwirtschaftliches Centralblatt, Hannover, 1888, pts. 18 and 19) states that a clear space often appears in bacilli with pointed ends. From agar cultures twenty-four hours old, at 37° C., the bacilli average 4 μ in length and 1.0 μ in breadth. On gelatine cultures, grown at 22° C., they are somewhat shorter. They grow singly, but occasionally form chains of various length.

Stains.—With the ordinary aniline stains the bacilli colour rather badly (Eisenberg, Bakteriologische Diagnostik, Hamburg, 1891, p. 298, and Klamann, Bienenwirtschaftliches Centralblatt, Hannover, 1888, pts. 18 and 19). The best stains are methylene blue and methyl violet. The bacilli accept Gram's stain, but the spores are not colored by it. I find the most satisfactory stain in methyl violet.

Capsule.—No capsule has been demonstrated by Welch's method.

Flagella.—The bacilli are actively motile and possess a single flagellum at one pole. The motility of the bacillus is quite pronounced in fresh cultures obtained from bouillon, agar, and gelatine. The flagella stain by Pitfield's, Loefflers's, and Van Ermegen's method.

Spore formation.—Spores are formed by the bacillus, and are large oval bodies averaging in length $\frac{1}{12000}$ inch, and in breadth $\frac{1}{23700}$ of an inch. On agar the spores are arranged in long rows, side by side, and are greater in diameter than the cells from which they are derived. The earliest appearance of spore formation takes place in forty-one hours, at 36° C. (Cheyne), but in some cases it is even sooner. The spores are formed in the center of the rod, and the formation occurs as follows: The rod begins to swell and become spindle-shaped. Occasionally the swelling is more marked at one end than in the center. The spindle-shape increases in size, and the center of the swelling gradually ceases to take the stain. The capsule of the spore is apparently formed within the rod and is not merely the outer part of the rod. In three or four hours the rod is seen to have almost or completely disappeared, although parts of the faint outline of the ordinary bacillus may be noticed.

Germination of spores.—Under favorable conditions the beginning of the germination of the spores takes place in about three hours. The spore loses its oval shape, becomes elongated, and is soon seen to burst through the spore capsule. It then presents the appearance of a short rod, with a pale envelope embracing one end. The rod gradually leaves the spore capsule, and then goes on multiplying as a full-grown bacillus. According to Eisenberg (Bakteriologische Diagnostik, Hamburg, 1891, p. 298) the spores are decolorized by the tubercle bacilli stain, but preparations may be obtained by using the Ziehl-Neilsen stain and alcohol for decolorization. The spores also stain by the method of Neisser.

Polymorphism.—Variations in size and shape may be brought about by growth in acid media, or in media containing different sugars. These variations occur also in the same culture, subjected to exactly similar conditions of growth.

Involution forms.—Abnormal forms are especially abundant when the bacillus is grown on blood serum; peculiar Y-like forms and clubbed shapes are of common occurrence, and relatively few spores are found.

BIOLOGICAL CHARACTERS.

Bouillon.—"In meat infusion at the temperature of the body they grow rapidly, causing muddiness and, after a few days, a slight but not tenacious scum" (Cheshire and W. Cheyne). In bouillon, with a reaction of +0.08 (Report of Convention of American Bacteriologists, Journal American Public Health Association, Vol. XXIII, 1898), at 37° C., there is a slight turbidity in fourteen hours, especially noticeable when the tube is shaken. In twenty-four hours, the liquid is uniformly turbid, with a very fine sediment. In forty-eight hours the turbidity increases and a pellicle commences to form. Reaction of the culture at this time, +0.07. After ninety-six hours the broth is clear, with a pellicle, white, rather massive, and somewhat tenacious. There is also much sediment. Reaction, after ten days' growth, neutral.

Glycerine bouillon.—Media with original reaction of +0.08. At 37° C. the bouillon becomes slightly turbid in twelve hours and quite turbid in twenty-four, with a fine, whitish pellicle on surface, which does not extend to the sides of the tube. If the culture is shaken, the pellicle deposits in flaky masses. The reaction is +1.2. In thirty-six hours the turbidity clears, leaving the media bright, with a smooth, thin, tenacious, and white pellicle on the surface. In many cases the pellice becomes very wrinkled and greasy looking. At the end of eight days the reaction is +2.2, and the bouillon is several shades darker in color, but quite clear. The reaction after fourteen day's growth is +4.2. At 22° C. the same changes occur, but growth is slower. The bacilli are relatively less numerous than in bouillon and are slightly shorter and thicker.

Glucose bouillon.—With a reaction of +2, at 37° C., the broth is more turbid than plain bouillon after fourteen hours' growth; and in twenty-four hours the sediment is heavy and turbidity very marked, but no pellicle. In forty-eight hours the media is opaque and cloudy, and the pellicle is beginning to form. In ninety-six hours the broth is less cloudy, but the sediment is heavier, and a white, thick pellicle is formed. It is often wrinkled, but not quite so much so as that on the glycerine broth. Reaction of broth after ten days' growth, +4.6. The bacilli are occasionally clubbed, and Y-like forms may occur. They average 5 μ in length and may be slightly curved.

Lactose bouillon.—With a reaction of +1.06, at 37° C., the growth resembles that of plain bouillon for the first twenty-four hours; but at the end of forty-eight hours, it is more turbid. In ninety-six hours, a tenacious pellicle forms, less massive than that on glucose broth. Reaction after ten days' growth, +2.4. The bacilli average 3.5 μ in length.

Saccharose bouillon.—With a reaction of +1, at 37° C., the turbidity and sediment are heavier than any of the other bouillons. In forty-eight hours the broth is quite opaque and whitish looking. A heavy sediment is then present, and pellicle formation is just beginning. In ninety-six hours the cloudiness is about the same, but there is an increase of sediment, and the pellicle is thin and membranous. Reaction of media after ten days' growth, +4.04. The bacilli average 5 μ in length.

Gelatine plates.—At 22° C., in twenty-four to thirty-six hours, the colonies are small, round, oval, or lozenge-shaped, with peculiar projections or shoots from one end of the colony, giving it a pear-shaped or tadpole-like appearance, according to the amount of development of the projection. In many cases several of these outgrowths occur from different portions of the colony. By placing a cover glass on the surface of the gelatine and using objective 7, the bacilli may be seen moving around and around the colony and to and fro along the projections. At the end of forty-eight hours the colonies are larger. Fine processes or projections are shooting out into the gelatine in all directions, forming peculiar figures in circles or club-like forms. "It is impossible," says Cheyne, "to give a proper idea of the appearance of the growth. The forms assumed are the most beautiful shaped I have ever seen; but they are very numerous, always retaining the tendency to form curves and circles." After a time the gelatine is liquefied and the beautiful appearance of the colony is destroyed by the liquefaction of the gelatin.

These peculiar shaped colonies are most typical when the germ is taken from the diseased larvæ. After prolonged cultivation on various kinds of media, there is a tendency for the colonies to become round, and the peculiar branching forms are not seen in such numbers. The composition of the gelatine also seems to make a difference in the appearance of the colonies. In gelatine containing 12 per cent gelatine the processes are not so long. The same effect may be brought about by using more peptone in the composition of the media.

Gelatine tubes.—In stick cultures at 20° C. growth occurs all along the line of puncture. On the surface delicate branching or ramifying growth occurs in three days. These outgrowths soon run together and the gelatine is liquefied, first around the line of puncture, and in five days extends over the whole surface. The growth in the depth of the gelatine occurs as a whitish streak all along the needle track, and from this numerous shoots and growths branch out into the gelatine in all directions, giving a haziness to the appearance of the gelatine, which then begins to liquefy. If the inoculation is a heavy one, the shoots are coarse and may have club-shaped extremities, and from these swollen ends fresh shoots may start. Cheyne obtained the most characteristic growth in gelatine containing 3 per cent of peptone as well as 10 per cent gelatine. The whole tube is liquefied in from two to four weeks' growth. The liquid becomes yellowish in color and gives off a peculiar odor. Klamann states that in gelatin acidified with lactic acid the growth is slow and long threads are formed.

Gelatine streak cultures.—In gelatine streak cultures the appearance is very similar to what one sees in stick cultures. The bacilli first grow along the line of inoculation, and then throw out shoots into the surrounding gelatine, producing the appearance noted in the stick culture. The bacilli move to and fro along the channels of liquefied gelatine.

Agar plates.—On agar plates at 37° C. the colonies at the end of eight hours are small and burr-like, with spines protruding in all directions, giving the colony the appearance of a sea urchin. In some cases the projections are from one side or end. At the end of twelve hours the colonies have well-defined projections, visible to the naked eye. The colonies in the depths of the agar are more spiny, the processes being much shorter. On agar plates streaked with a light inoculation most beautiful forms occur. The growth of the bacilli spreads over the surface and branches repeatedly, giving the appearance of seaweed. This appearance is distinctly characteristic; and as the growth is very rapid, this method commends itself for making a quick diagnosis of the presence of the bacillus in larvæ supposed to be diseased.

Potato cultures.—On potatoes the growth differs considerably, according to the reaction and age of the potato. Sometimes a brownish wrinkled growth forms, which gives off a peculiar odor; at other times a dryish yellow layer appears. "The bacilli grow very slowly indeed at 20° C." (Cheyne, Journal of the Royal Microscopical Society, 1885, p. 381). Even at 37° C. they grow slowly.

Milk.—In milk at 37° C. coagulation of the casein occurs in three days. The milk becomes yellowish and gives off a characteristic odor. After several weeks' growth the curd is digested and a whey-like fluid remains.

Blood serum.—On blood serum at 37° C. the growth is rather slow and polymorphic forms are common. "Very long filaments are formed" (Cheshire and W. Cheyne, Journal of the Royal Microscopical Society, 1885, p. 381). These long forms may be from five to ten times as long as the average bacillus growing on gelatine, and consists of single cells. The filaments are often wavy or twisted and of unequal thickness. The extremities of the long, bent rods are often clubbed; and Y-like forms are numerous. Spores are formed very sparingly, and the blood serum is liquefied.

Synthetic media (Uschinsky).—In Uschinsky's medium no growth occurs; but if the medium is neutralized, good growth ensues. The bacilli occur in threads and a pellicle is formed.

Dunham's solution.—The bacilli are small when grown in this solution. No threads form, but there is a slight indol reaction after nine days' growth.

Relation to free oxygen.—Cheyne states that the germs grow most rapidly on the surface of agar and arrange themselves side by side; and they produce spores in this position after a few days' growth. Eisenberg (Bakteriologische Diagnostik, Hamburg, 1891, p. 298) says nothing under the head of aerobiosis. Howard (Foul Brood: Its Natural History and Rational Treatment, Chicago, 1894) writes that, "It grows best under anaerobic conditions; is a facultative aerobe; grows under the mica plate, and in the presence of oxygen the growth is slight and slow." Howard also states that under anaerobic conditions it emits a foul odor resembling that of foul brood. It will be thus seen that Cheyne and Howard do not agree on this point. The former author also says that the characteristic odor is given off under aerobic conditions, whilst Howard states that this smell is emitted under anaerobic conditions. Further, Cheyne states that the bacilli grow with great rapidity on the surface of agar, whereas Howard obtains his best growth under the mica plate, which does not give complete anaerobiosis. Howard's conclusions are thus at variance with Cheyne's, and my own results fully corroborate those of the latter author.

Howard states that the vitality of the spores of *B. alvei* is destroyed when exposed to atmospheric air from twenty-four to thirty-six hours. In making his experiments he took sterilized road dust and mixed it with the dry foul-brood masses from several cells, which were previously dissolved in distilled water. The mixture was worked dry and spread on sheets of paper, and trial cultures were made immediately and at intervals of every twelve hours for three days; and, according to his results, no growth occurred after thirty-six hours. In giving these results, Howard does not state whether he exposed the spores to sunlight or diffused light; nor does he mention the age of the dry foul-brood masses, which he used from several cells. These are points of considerable importance, for, as everyone knows, the disinfecting power of direct sunlight is much greater than diffused light, and the vitality of the spores from foul-brood masses of different ages varies considerably. This, I may add, has been clearly shown by some of my experiments, subsequently described. In my experiments the spores obtained from a pure culture on the surface of agar were spread on cover glasses and placed in a glass chamber, so arranged that a current of air was constantly circulating over them. This chamber was exposed to the ordinary light of a room with six large windows, and a cover glass was taken out every twenty-four hours and tested, to see if the spores would grow. This experiment was continued for one month, and at the end of that time the spores still germinated rapidly. In another experiment, spores spread on cover glasses were exposed to a very diffused light, simulating, as far as possible, the amount of light which would enter a hive. Cover glasses were taken out from time to time and transferred to agar, in order to ascertain if the spores were alive or not. The experiment was begun two years and four months ago, and from the last cover glass taken and placed upon the surface of an agar plate a copious and typical growth of *B. alvei* was obtained. Further, thin strips of filter paper, plunged into a bouillon culture and allowed to dry, were threaded on a wire suspended in a wire basket and so exposed that the air could freely circulate around them in the ordinary light of a room. Trial cultures were made at intervals, and at the expiration of six months the spores from the paper germinated when strips were placed on the surface of agar.

Again, a drop of bouillon containing spores was placed in a sterile tube and allowed to dry; and at the expiration of one hundred and twenty-four hours (thirty-six of which were in sunlight at a temperature varying from 30° to 37° C.) sterile bouillon was added. The tubes were then placed in the incubator, and in less than twenty-four hours a good growth of the germs had taken place.

From these experiments it will be seen that the results are directly at variance with Howard's statement, as they go to show that the vitality of the spores of *B. alvei* is not destroyed by exposure to atmospheric air, with or without sunlight, for even a much longer time than twenty-four to thirty-six hours.

With regard to the aerobiosis of this bacillus, good growth has been obtained in an atmosphere of hydrogen by Novy's method. Buchner's method also gave good results. The growths in the various media are very similar to those produced under aerobic conditions, but with this difference, that the surface growths are, as a rule, whiter in the hydrogen atmosphere. In illuminating gas (water gas) no growth occurred, but the spores were not destroyed by the action of the gas; for when the gas was let out of the Novy jar, good growth ensued on all cultures. In acetylene gas, a restricted growth occurred. In fermentation tubes growth occurred both in the open and in the closed arm of the tubes. No gas was formed, the bouillon in the closed arm was uniformly turbid. Thus *B. alvei* is a facultative anaerobe.

Production of alkali.—In ordinary bouillon a slight amount of ammonia is formed. Control bouillon did not give the Nessler test. In glycerine and the sugar bouillons, there is no trace of ammonia. Cheyne's cultures are faintly alkaline, both before and after inoculation in meat infusion. Klamann states that ammonia is produced.

Acids formed.—A varying amount of acid is formed. All the sugar bouillons give an acid reaction.

Formation of pigment.—On potatoes a yellowish growth is produced; on all other media, the surface growth is white.

Development of odors.—Cheyne states that gelatine cultures give off an odor of stale, but not ammoniacal urine, or what may be better described as a shrimpy smell; and this peculiar odor has been found by Cheshire to be distinctive of diseased larvæ. Klamann and Howard both state that a peculiar odor resembling that of the diseased larvæ may be noticed in artificial cultures.

The effects of desiccation.—I have already noticed, under the head of "Relation to free oxygen," that the spores of *B. alvei* have considerable vitality in withstanding desiccation. My experiments prove conclusively that the spores are extremely hard to kill by desiccation and in this respect resemble those of anthrax, which are known to resist thorough desiccation for a number of years. One experiment which showed this characteristic was as follows: An agar plate completely covered with a typical growth of *B. alvei* was allowed to dry out completely, and was left exposed to the ordinary light of the room for seven months, and at the end of that time, a portion of the film was scraped off with a knife, placed on suitable medium and incubated, with the result that a typical growth immediately ensued.

Spores on cover glasses were exposed to September sunlight (latitude 43°) for varying periods of time, and growth occurred after four, six, and seven hours' exposure. The age of the spores varied from five days to eighteen months; and spores three months old were not killed by seven hours' exposure.

From the symptoms given in this paper the disease with which Professor Harrison worked was doubtless American foul brood. From the discussion of geographical distribution this is also evident, for he says: "I have examined diseased larvæ from Canada, from Europe, * * * Cuba, and thirteen States of the Union, ranging from New York to California and from Michigan to Florida." American foul brood is thus widely distributed, but from all these specimens Professor Harrison obtained a bacillus which he called *Bacillus alvei.* Since we now know that *Bacillus alvei* is found in European foul brood and not in American foul brood, it is evident enough that the germ must have been another bacillus. European foul brood, as far as the author is able to learn, is not found in Canada nor Cuba, and, although now found in several States in the northeastern United States and spreading, is not, as Professor Harrison would have us believe, widely distributed in the United States.

How can this be accounted for? The only way open seems to be in the identification of the bacillus. I do not feel qualified to pass judgment on the accuracy of the description of Professor Harrison, but the matter has been referred to Doctor White, and he assures me that the description just quoted fits the bacillus which is described as *Bacillus A* as well as it does *Bacillus alvei.* If this is true, we can only conclude that Professor Harrison, not knowing of the existence of two diseases, made a serious error in his identification. In no place does he speak of any difficulty in obtaining cultures from American foul brood. For comparison, Doctor White's description of *Bacillus A* (possibly *B. mesentericus*) is here quoted.

BACILLUS A.

(*B. mesentericus?*)

Occurrence.—Found very frequently on combs, on scrapings from hives, and on the bodies of bees, both diseased and healthy.

Gelatin colonies.—Very young colonies show irregular edges, but very soon liquefaction takes place and the colony gives rise to a circular liquefied area, covered with a gray membrane, which later turns brown.

Agar colonies.—Superficial colonies present a very irregular margin consisting of outgrowths taking place in curves. Deep colonies show a filamentous growth having a moss-like appearance.

Morphology.—In the living condition the bacilli appear clear and often granular, arranged singly, in pairs, and in chains. The flagella are distributed over the body. The rods measure from 3μ to 4μ in length, and from 0.9μ to 1.2μ in thickness.

Motility.—The bacilli are only moderately motile.

Spores.—Spores are formed in the middle of the rod.

Gram's stain.—The bacilli take Gram's stain.

Oxygen requirements.—Aërobic and facultatively anaërobic.

Bouillon.—Luxuriant growth in 24 hours, with cloudiness of medium; a gray flocculent membrane is present. Later, the membrane sinks and the medium clears, leaving a heavy, white, flocculent sediment, with a growth of the organisms adhering to the glass at the surface of the medium. Reaction alkaline.

Glucose.—Luxuriant growth takes place in the bulb, with a moderate, flocculent growth in closed arm. The gradual settling of the organisms causes a heavy white sediment to form in the bend of the tube. The reaction is at first slightly acid, but subsequently becomes alkaline. No gas is formed.

Lactose.—Reaction alkaline.

Saccharose.—Reaction alkaline.

Levulose.—Reaction acid.

Maltose.—Reaction acid.

Mannite.—Reaction alkaline.

Potato water.—Reaction alkaline.

Agar slant.—A luxuriant growth takes place on this medium. The growth gradually increases to a moist, glistening one, being then friable and of a grayish brown color.

Serum.—A luxuriant, brownish, glistening, friable growth spreads over the entire surface. No liquefaction is observed.

Potato.—An abundant fleshy growth of a brown color spreads over the entire surface. The water supports a heavy growth. The potato is slightly discolored.

Milk.—Precipitation takes place rapidly, followed by a gradual digestion of the casein, the medium changing from the top downward to a translucent liquid, becoming at last semitransparent and viscid.

Litmus milk.—Precipitation of the casein takes place usually within 24 hours, followed by a gradual peptonization. Reduction of the litmus occurs rapidly, leaving the medium slightly brown; later the blue color will return on exposing the milk to the air by shaking. Reaction alkaline.

Gelatin.—An abundant growth takes place with rapid, infundibuliform liquefaction. A heavy, white, friable membrane is formed on the surface of the liquefied medium. A flocculent sediment lies at the bottom of the clear liquefied portion.

Acid agar.—Growth takes place.

Indol.—None has been observed.

Nitrate.—Reduction to nitrite is positive.

Dr. William R. Howard, of Fort Worth University, Fort Worth, Tex., has published several papers on the bacteriology of bee diseases. In a paper published in 1894 (York Publishing Company, Chicago) he attributed " foul brood " to *Bacillus alvei.* Evidently he was dealing with American foul brood, and we now know that *Bacillus larvæ* is present in that disease.

The same author undertook to determine the cause of pickle brood and described a specific fungus, *Aspergillus pollinis.* No investigator has since been able to find any such fungus in similar specimens.

In 1900 (Gleanings in Bee Culture, p. 121) this author published an account of some brief and entirely inadequate investigations made on what he chose to call "New York Bee Disease, or Black Brood." A specific organism, *Bacillus milii,* is described, but the view is expressed that this is modified, perhaps, by *Bacillus thoracis.* During the investigations of the Department of Agriculture it has been learned from whom Doctor Howard got his specimens, and the same men have furnished specimens which they declare to be of the same diseased condition as those furnished Doctor Howard. These, however, contain *Bacillus alvei,* and the disease is the same as that described by Cheyne, now named European foul brood.

It is most unfortunate for Doctor Howard that in not a single point have his descriptions been verified. Certainly it would seem unwise in him to put out the names *Bacillus milii* and *Bacillus thoracis* as new species without descriptions and after so short an investigation. We can not, therefore, sympathize very much with him when his views are overthrown.

The American bee journals and text-books on apiculture have until recently contained statements to the effect that *Bacillus alvei* is the cause of the disease which has been almost universally called " foul brood." This is due not only to the publications of Mackenzie, Harrison, and Howard, but very largely also to the attempt to determine *Bacillus alvei* by microscopic examination. The best-known case of this is probably the examination of diseased brood made by Mr. Thomas William Cowan, editor of the British Bee Journal. On a visit to Medina, Ohio, Mr. Cowan was shown a sample of diseased brood, and after a microscopic examination he announced that he found *Bacillus alvei,* and that the diseased condition is identical with that found in England. That this ropy type (for such it was) is found in England can not be doubted, but that the germs which Mr. Cowan saw were *Bacillus alvei* may well be doubted. I have taken particular pains to ask Mr. E. R. Root, who was present, whether Mr. Cowan made a cultural examination, and was assured that the microscopic examination was the only one made.

The announcement of this examination in Gleanings in Bee Culture and the A B C of Bee Culture, coupled with the excellent reputation of Mr. Cowan, made this appear convincing to American bee keepers. It must be remembered, however, that at that time no one had questioned the presence of *Bacillus alvei* in American foul brood and on finding bacilli the conclusion that they were *Bacillus alvei* was natural, even though erroneous.

Mr. Edward Bertrand, in his book "Conduite du Rucher," makes a similar announcement, stating that he and Mr. Cowan examined brood described as ropy and found *Bacillus alvei.*

[Mr. DADANT: I have received a letter from Mr. Bertrand. He informs me that they (Mr. Cowan and himself) had examined foul brood, but I know from the tone of the letter that no cultures were made.]

To indicate how much reliance may be placed in microscopic examinations in the absence of cultural tests, let me quote from Sternberg's Text-book of Bacteriology, 1901 edition, pages 13 and 14. It should be borne in mind that this refers to all microscopic examinations of bacteria and not specifically to bee diseases.

> The bacteria are also classified according to their biological characters, and it will be necessary to consider the various modes of grouping them from different points of view other than that which relates to their form. This is the more important, inasmuch as we are not able to differentiate species by morphological characters alone. Thus, for example, there are among the spherical bacteria, or micrococci, numerous well-established species which the most expert microscopist could not differentiate by the use of the microscope alone; the same is true of the rod-shaped bacteria. The assumption often made by investigators who are not sufficiently impressed with this fact, that two micro-organisms from different sources, or even from the same source, are the same because stained preparations examined under the microscope look alike, has led to serious errors and to much confusion. As an example of what is meant, we may refer to the pus organisms. Before the introduction of Koch's "plate method" micrococci had been observed in the pus of acute abscesses. Some of these were grouped in chains—streptococci—and some were single, or in pairs, or in groups of four; but whether these were simply different modes of grouping in a single species, or whether the chain micrococci represented a distinct species, was not determined with certainty. That there were in fact four or more distinct species to be found in the pus of acute abscesses was not suspected until Rosenbach and Passet demonstrated that this is the case, and showed that not only is the streptococcus a distinct species, but that among the cocci not associated in chains there are three species which are to be distinguished from each other by their color when grown on the surface of a solid culture medium. One of these has a milk-white color, one is of a lemon-yellow color, while the third is a golden-yellow.

This brings us down to the work of Doctor White. His investigations were begun with Dr. V. A. Moore in 1902, and in January, 1903, a preliminary report was published. During the first year specimens of "black brood" were examined and to the surprise of the investigators *Bacillus alvei* was found in every case. Obviously, then, they were working with the foul brood of Cheshire and Cheyne (European foul brood). In a second short paper by Doctor White a brief note is given concerning some work done on the "ropy type" of foul brood. He recognized that he was dealing with a disease the cause of which had not been described and the disease is called for the time "X brood" and the bacillus, *Bacillus X*. The final results of the investigation appear in Technical Series, No. 14, Bureau of Entomology, under the title "The Bacteria of the Apiary, with Special Reference to Bee Diseases." Doctor White's description of *Bacillus larvæ* is as follows:

BACILLUS LARVÆ.

Occurrence.—Constantly present in diseased brood from colonies affected with American foul brood.

Gelatin.—There is no growth.

Morphology.—It is a slender rod, having a tendency to form in chains. This is especially true when grown in bee-larvæ bouillon.

Motility.—The bacillus is rather sluggishly motile.

Spores.—Spore formation takes place. This can be observed best in the different stages of the disease and decay of the larvæ.

Oxygen requirements.—When Liborius's method is used, the best growth usually appears near to but not on the surface. After a few generations a surface growth may be obtained.

Bouillon.—There is no growth.

Glucose bouillon.—There is no growth.

Lactose.—There is no growth.

Saccharose.—There is no growth.

Agar plate.—There is no growth.

Bee-larvæ agar.—The inoculations must be made with the medium liquefied. The growth takes place near to but rarely on the surface. Cultures must pass through a few generations before a satisfactory surface growth can be secured.

Bee-larvæ agar slant.—On the surface of this medium a thin, gray, nonviscid growth takes place.

Glucose agar.—Slight growth has been observed in the medium. No gas is produced.

Potato.—There is no growth.

Milk.—There is no growth.

Litmus milk.—There is no growth.

Fermentation.—In bee-larvæ bouillon no gas is produced.

Indol.—There is no growth in sugar-free bouillon.

To summarize, then, *Bacillus alvei* is found universally in European foul brood; *Bacillus larvæ* in American foul brood. No specific micro-organisms have been found for the so-called pickle brood or paralysis. Knowledge of the two worst brood diseases is accurate enough to enable us to combat them by applying principles acquired by comparison with results of work with other micro-organisms.

That our knowledge is complete is far from true. Not only is there much to be learned which is of purely scientific interest, but points of the highest practical importance are yet undetermined.

[NOTE.—Several other papers of importance have been issued on this subject which were not discussed at the Inspectors' meeting. They, however, have an important bearing on this subject. Lambotte decided that *Bacillus mesentericus vulgatus* causes "foul brood," or, in other words, that *Bacillus alvei* is but a variety of *Bacillus mesentericus*. His work, however, is far from convincing. The principal point of interest in this regard is that he had great difficulty in getting a growth from the ropy type of foul brood (American foul brood) on ordinary media. Burri in 1904 published an account of his work and found *Bacillus alvei* in a few specimens from Switzerland (indicating that European foul brood is found there), but found another organism which grows with difficulty; the latter is undescribed and unnamed, and it is possible and probable that he worked with *Bacillus larvæ* White. Maassen (1906) found the same difficulty, isolating *Bacillus alvei* in only 13 specimens of diseased brood out of 112 received. He, too, found an organism which could be made to grow on ordinary media only with difficulty and called by him *Bacillus brandenburgiensis*. It is undescribed, so far as is known to the writer. He also claims to have found another organism, *Spirochæte apis* Maassen, but has not established any causal relationship.

These papers all tend to confirm the work of Doctor White. *Bacillus alvei* is not found in the ordinary ropy type of "foul brood," but another organism is; this is probably the *Bacillus larvæ* of Doctor White.

In the face of all these facts several prominent bee men of England are attempting to discredit all this work, the criticism, so far as is known to the writer, being based entirely on comparisons of literature and on an entire lack of investigation. They have, further, misread the papers issued by the Department of Agriculture on this subject. It seems entirely unnecessary, therefore, to review the criticism in detail.—E. F. P.]

EXISTENCE OF BOTH AMERICAN FOUL BROOD AND EUROPEAN FOUL BROOD IN THE SAME COLONY.

Mr. ATCHLEY. Do you think that both diseases, American foul brood and European foul brood, could exist in the same colony?

Doctor PHILLIPS. Reports are sometimes received that a colony is infected with both diseases at the same time, but this is contrary to the experience of those persons most conversant with these conditions. While it may be possible for a colony to have the infection of both diseases at the same time, it is not by any means the rule, and such cases are probably not authentically reported.

Both diseases are found in New York State. The inspectors have to treat both diseases and they treat both in the same way, but they have never found both diseases in the same colony.

GEOGRAPHICAL DISTRIBUTION OF AMERICAN FOUL BROOD.

Mr. DADANT. Is not the American foul brood spread more over the world?

Doctor PHILLIPS. It would seem so from the literature. It is found in almost every State of the Union, while European foul brood is, as far as is known, found only in the States mentioned a while back.

Mr. **Dadant**. The American foul brood is characterized by the ropy condition. The French name for their common brood disease is "loque," meaning tatters, and this name therefore refers to what we call American foul brood.

Mr. **Coggshall**. Which of these diseases is the one found in Cuba?

Doctor **Phillips**. That is the American foul brood. It has the typical ropy character.

EFFECT OF CLIMATE ON VIRULENCE.

Mr. **L. F. Juneau** (Colorado). I would like to ask if brood diseases are equally bad in all States or has climate anything to do with the virulence of the diseases?

Doctor **Phillips**. Climate undoubtedly makes a great difference. The American foul brood of California is not anything like the same disease in the East. It is simply terrible in California. Mr. Rankin will tell us about that later in the day. It is the same disease, but its ravages are much worse.

Mr. **Juneau**. Mr. T. L. Thompson (Colorado) sent some pickle brood to Dr. W. R. Howard, and the latter called it "black brood," but said: "In your State it will not be so bad."

Doctor **Phillips**. It was probably not European foul brood. That disease has not been found west of the Mississippi River.

ASSOCIATION OF INSPECTORS OF APIARIES.

It was decided that it would be well for the inspectors of apiaries of the various States to be organized in some way to bring about greater cooperation in the work. After discussing the question it was finally decided that Mr. N. E. France, inspector of apiaries for Wisconsin, should act as chairman of a committee on organization and appoint his own associates.

SECOND SESSION, HELD MONDAY AFTERNOON, NOVEMBER 12, 1906.

Doctor **Phillips**. In the morning session we covered rather thoroughly the scientific side of investigations on bee diseases. That is, of course, important; but when it comes to the practical work on bee disease there are two subjects of much greater importance, namely, methods of treatment and legislation. We will first discuss the treatment of these two brood diseases and then take up the discussion, in so far as we can, of the laws now existing, with suggestions as to the form which a law should have to give the best results and the powers which should be given to the inspectors under the various conditions which may arise. I have, however, a paper that I wish to read first, which was written by Mr. Charles Stewart, of Sammonsville, N. Y., one of the inspectors of that State. I had the pleasure and privilege of spending four weeks in the field with Mr. Stewart last spring, and I feel that I can say that if there are any good inspectors in the United States one of them is Mr. Charles Stewart. Mr. Stewart is exceedingly sorry that he can not be here, and he requested me to read this paper to you.

APIARY INSPECTION IN NEW YORK STATE.

By CHAS. STEWART,
Inspector, Third District.

BROTHER INSPECTORS: It is with a feeling of regret that I write this paper, knowing that it will be impossible for me to be with you at what must be both a pleasant and profitable meeting.

It is hardly necessary for me to describe European foul brood nor to refer to its entrance into New York State, except to say that it was brought in some years ago by a shipment of bees from one of the Southern States, and just as we were feeling that we had nearly stamped it out and were masters of the situation we discovered that at least one if not two fresh importations had been made in a section of the State where no trouble of this kind formerly existed.

I wish to call your attention to the fact that no bee keeper can feel reasonably safe from infection until every State in the Union is under the surveillance of a keen-eyed inspector who knows every spot of disease in his jurisdiction and allows no bees to be shipped out of such territory. Had the inspectors of New York State not adopted this rule, disease would have spread not only all over our State, but to far distant points, as many, fearing the loss of their apiaries, were eager to sell at a sacrifice. In order not to make this rule a hardship to our people, we have made it a practice to find a buyer within the diseased territory competent to cure the disease and so keep our troubles within our own family.

I wish I had the power to paint to you in words the pathetic picture when four good men and true, who had been bee keepers from boyhood and had large interests to protect, took up this work. I have seen the faces of strong men blanch with fear or turn crimson with anger at the first visit of an inspector, and later, when their bees were saved and their product marketed, the young man sent back to college, their little children cared for, or perhaps the home saved, these same men with tears on their cheek would give one a hand clasp that was far more eloquent than words and possesses a value beyond gold. I question if there is an inspector present to-day who from a mere money point of view would not be better off if he had given his entire time to his own business; yet I honor this American spirit you possess in that, having once started out to accomplish results, you refuse to turn back until the end is attained.

I hardly feel like posing as an instructor to this gathering of inspectors, but will call your attention to a few important points. A question often asked is, "How does the disease spread so rapidly?" I would answer, "By means of infected honey." No field bee from an infected colony goes out with its honey sack so empty of honey that it contains no germs, and on their return many bees mistake their hive and carry disease to their near neighbors in the same apiary, so that it is a common thing to find a badly infected colony and those in the same row infected in proportion to their distance from the source of contagion.

How the disease spread from yard to yard when no robbing took place was for a long time a puzzling question, until I found an apiary of black bees 3 miles from an apiary of golden Italians that were infected. In many colonies of the yard of blacks could be found a sprinkling of the golden Italians and in nearly every case these colonies showed traces of disease. Evidently bees are often driven by stress of weather or some other cause to seek shelter far from home, and thus disease may be spread.

We have found no bees immune from disease, yet some vigorous strains of Italians are nearly so. For years we have recommended the introduction of young Italian queens, but have warned the owner of an infected apiary not to depend on that alone, as it would prove disastrous in localities where the disease has just made its appearance and the bees are mostly black. This method will often prove very successful where European foul brood has existed for some time and lost much of its virulence, but, like the use of drugs, it is not a safe method for the inspector to advocate, while the shaking method has never failed us if done in a thorough manner. Colonies that are found to be diseased late in the season may be cured by taking away all their combs after brood rearing has ceased and giving them clean combs from a healthy colony, as any disease germs that are contained in the honey sack will have been eliminated long before brood rearing commences in the spring.

In conclusion I would say that to be successful as an inspector a man should not only be well versed in the management of bees and bee diseases, but he must be broad minded, even tempered, possess a liberal amount of tact and diplomacy, and be a shrewd judge of human nature. Yes, and even more, he should be able to win the confidence of others and share their burdens, and when the time draws nigh when the working tools of life shall drop from his nerveless clasp he may look back with satisfaction to a life well spent in the service of others.

Doctor **Phillips**. When the notices were first sent out concerning this meeting I wrote to Mr. Fred A. Parker, of Lompoc, Cal., under the impression that he was inspector of Santa Barbara County. It seems that he has resigned and Santa Barbara County now has no inspector. He has, however, sent a paper, which will now be read:

AMERICAN FOUL BROOD ON THE PACIFIC COAST.

By **Fred A. Parker**,
Former Inspector for Santa Barbara County, Cal.

During my term as inspector of apiaries for Santa Barbara County, Cal., in the year 1905, 4,073 colonies of bees were inspected. I discovered 47 cases of American foul brood and found 170 colonies not on movable frames. These were ordered transferred, and in some instances I did the work myself. Every case of foul brood was either burned or treated by the shaking method. Five were burned, being too weak in numbers to treat. Preparatory to burning, I would dig a hole about 2 feet deep and build a fire in it, then throw in the frames containing the diseased brood. After the fire did its work the hole was filled with dirt to prevent bees from getting diseased honey, if any might have been left unconsumed. If any comb was attached to the hives the latter were placed on the fire in the hole and when the interior was a mass of flames they were removed with a shovel, hoe, or other long-handled tool and water thrown on to extinguish the flames if the wood had caught fire. The bees were shaken into an empty hive and allowed to build comb on the lid for three days, when they were shaken onto frames with starters and allowed to proceed. The comb was scraped from the lid and the lid scorched. This treatment, if carefully performed, is successful in about nine-tenths of the cases treated. Bee keepers are generally too careless in handling the diseased combs, thus giving other bees an opportunity to steal a load of infected honey.

I have read many statements to the effect that queens do not carry the infection, but my experience has convinced me otherwise. I had shaken six diseased colonies in my own apiary in 1902 and four were completely cured. While I was equally careful in handling these cases the disease reappeared in two of them. I shook them again, and again in due time the disease appeared. This caused me to suspect that the queens were defective, and to test it I exchanged them with the queens of two perfectly healthy colonies, shaking the diseased stock again. In both cases the cure was complete, while the disease appeared in the brood of the formerly healthy colonies. This appears to me to demonstrate beyond doubt that the ovaries of queens are occasionally infected, that their eggs transmit the germs of American foul brood, and that the disease will develop in any colony to which they are introduced. If this occurs in one-third of the cases or one-tenth, it will pay to requeen in every case, unless you have an especially valuable queen you want to save, in which case it may pay to experiment. For that reason I now practice requeening every colony treated for American foul brood.

My experience with drugs has been unsatisfactory in every case. I have tried carbolic, rosemary, Bingham's sulphur plan (as outlined in Gleanings in Bee Culture, April 15, 1902), the formaldehyde spray plan (Gleanings in Bee Culture, December 1, 1903), and naphthol, but while all these drugs have the effect of checking the disease and preventing its spread over the combs as long as used, none of them cures it, regardless of the duration or persistence of its application.

I have not tried the formalin-gas plan, nor do I intend to try it, or any other drug treatment, so long as the shaking treatment will cure. While destruction of frames and combs is expensive, it is to my mind cheaper in the end than experimenting with every new cure that is exploited in the bee journals. After trying these you are forced to resort to the shaking treatment to make the cure complete, so why not use it at first and save the trouble and expense? So long as honey contains spores, so long will drugs fail, because they can not reach and destroy the spores. Even if a temporary cure could be effected the disease would reappear when the bees began feeding the larva this germ-laden honey. Nothing short of removing all the combs will make the cure permanent.

As an apiarist I have had experience in many infected apiaries, and in every yard where the disease has ever been, with one exception, a few cases develop every season, and will continue to do so until these old combs are retired. If a whole apiary is to be treated, it pays to save the wax and honey, but I do not believe in bothering with them if only a few hives are to be treated; it does not pay to take the trouble. Of course progress is desirable, and I would not discourage anyone who wants to experiment with drug treatments, but I believe if any good is ever derived therefrom, it will come from the work of experiment stations or trained scientists, who have the means and time to devote to it and do not have to depend on apiculture for a living.

American foul brood seems to act differently here than in most places. The question may arise, Is it American foul brood? It has the sunken, perforated cappings and the foul, glue-like odor, and it ropes from one-eighth to several inches. I have seen many cases where the brood chamber was badly affected with foul brood, but when a honey flow came, the queen moved up and not one cell of disease appeared. I have known these bees to cast strong swarms, which proved to be entirely healthy.

Again, I have known American foul brood to disappear without any treatment whatever. Mr. B. Dickens, one of the most intelligent and observing apiarists, had marked a colony for treatment. Not being able to attend to it for several weeks, he was surprised when he did open it to find every trace of the disease gone. I had the same experience this season. The most amazing case of this character, however, was the experience of Mr. W. J. Oates (now my business partner) in 1903. He purchased an apiary of 30 colonies, nearly every colony being badly affected with foul brood. The former owner, Mr. J. H. McGee, desired to get rid of the colonies, not caring to go to the trouble of shaking them. Mr. Oates treated the whole apiary by the shaking treatment. As soon as there was sealed brood in the hives, it was seen that disease had developed in about three-fourths of them. I examined these colonies myself, and if they did not have the disease after the shaking, then I never saw a case of American foul brood. Mr. Oates did nothing more to them, and, becoming disgusted with the proposition, he sold out to Mr. F. S. Moorehead and went to Nevada. The year 1904 was a poor season here, and honey was extracted from these hives once, I think. Nothing was done for the disease. In 1905 I inspected these bees, expecting to find them reeking with disease, but to my surprise I could not find a single case of foul brood; it had completely disappeared. Mr. Oates was surprised when informed of this, but he managed this apiary that season on the shares, and no disease developed. I had occasion to look through this apiary just last week, and not one case of disease exists there to-day. That is a case I can not understand, unless it is that by the shaking the bees were relieved of all diseased honey, and, being shaken in the fall, the queens ceased laying entirely later, and the bees cleaned out all infection. But I am unable to account for the wholesale reappearance of the disease, unless the treatment was carried out in a careless manner. I am certain that the circumstances occurred just as related. The Simmins plan is not a drug plan, and I intend to test it next season, if I find any American foul brood.

Sometimes disease spreads quite rapidly here, infecting one-half or more of the colonies in two seasons. Then I know of some apiaries where a few cases have existed for years without any perceptible increase. I know of one instance where an apiary was entirely destroyed by the disease in one season. Whether our climatic conditions have anything to do with the matter I do not know, but it is a fact that foul brood as it exists here is of a very erratic nature. Furthermore, it is dangerous, and a relentless war should be waged against it until it is exterminated.

A paper entitled "The appointment of inspectors," by Fred A. Parker, of California, was then read, in which the writer showed that the work of the inspector is far from easy. Many bee keepers criticize the work of the inspector as soon as their apiaries are examined, and fault is found with inspection and the inspectors. It is the duty of the bee keeper to uphold the inspector as long as he is doing honest work for the bee-keeping industry. The salary paid an inspector is in most cases smaller than the income he could make by remaining at home and doing the required work in his own apiary, so that inspection is usually done at a financial loss to the inspector.

Mr. J. M. RANKIN (California). It has been my privilege since May, 1905, to be in touch with bee-disease work on the Pacific coast. During this time I have visited many diseased apiaries throughout the State of California.

Few eastern people have an adequate conception of the bee-keeping industry in California. It is not an uncommon thing for one man to own 4,000 colonies of bees. This, of course, puts the business on an entirely different footing than in the East. In the same way, conditions of disease are also different. The control of American foul brood among so many colonies becomes a much more difficult proposition than it is where the bee keeper owns only fifty to seventy-five colonies. There seems to be no doubt, also, that the American foul brood is much more virulent in California than in the East. Whether this is due to some climatic condition or not, I do not know. I have seen an apiary showing only slight infection in February become almost a total wreck in August. In California, also, the bees fly nearly 300 out of the 365 days in the year, and the honey flow in most parts of the State is of comparatively short duration. This makes conditions favorable for more rapid infection than in colder climates where the bees are confined to their hives during about half of the year.

Under such conditions you can readily see that treating the disease is difficult. It must be done at exactly the right time and under favorable conditions or the treatment is worse than useless. Some of the best inspectors in California use the shaking treatment, and all of them shake twice, as well as disinfect the contaminated hives. There are some few men who do not believe in treating by this method and who burn all diseased colonies, only saving hives when these are in good condition. In counties where bees can be bought for 50 cents a swarm it may not be a bad plan to destroy all diseased colonies, as this is certainly an effective treatment if the burning is complete.

A treatment very favorably thought of by some is that of thoroughly boiling all diseased material. A large tank is used and the diseased colonies, after having been sulphured the night before, are carried to the tank and all the combs thrown in. After all the wax is melted, the frames are removed from the tank and placed on the fire under the tank as fuel. This is certainly an effective way of eradicating the disease and can be recommended more highly than the burning plan, as by this means the wax is not destroyed.

California has the county system of inspection, and probably the smallest number of colonies which one inspector has to look after is 30,000. From that number the colonies run up to 150,000 in a single county.

Doctor PHILLIPS. What Mr. Rankin has just said is in line with my own observation during the middle of the summer. I visited one apiary in Ventura County, with Mr. A. G. Edmondson, the inspector for that county, and he showed me 151 hives. Two years ago this apiary was in the hands of a competent bee keeper and no disease was present. Ventura County is so large that the inspector can cover only one half in one year and the other half the next year. When we examined the apiary we found 15 healthy colonies and 136 hives in which the bees were dead or nearly so.

TREATMENT FOR BEE DISEASES.

In discussing the methods of treatment, it would be a good plan to call on each of the inspectors present and get each one to tell what method he employs. We should hear first from Mr. N. E. France, inspector from Wisconsin. He is the oldest inspector in the United States in point of service.

Mr. FRANCE. Referring to the paper which was just read, I have tried some of the methods of using drugs in the apiaries of competent bee keepers and invariably all these methods are failures in Wisconsin. The fumigating with formalin seemed for a time to check the disease, as did also some of the other drugs, but in the end they all are failures. The one method that has given universal satisfaction we owe to the oldest inspector in America, Mr. William McEvoy, of Ontario, and it has often been termed the "McEvoy method." The plan is to remove the bees from the infection and keep them away long enough to use up whatever infected honey there is in the stomach of the bee.

I am not satisfied to stop with finding disease in a yard and immediately prescribing treatment. In fact, I seldom, after looking over the yard and finding the disease, begin to prescribe treatment, for I feel that we are not yet ready for it. What is the use of treating when some neighbors might have diseased colonies? Take a wide circuit; then treat at once all colonies having disease. This has sometimes vexed the bee keepers, for they want me to stay and show them what to do at once, but I tell them that I see no good in treating colonies while leaving another source of infection.

I try first to instruct the owner of the bees to be careful in his management. If, in my judgment. he is one who keeps the apiary clean, and if I can depend upon him, I sit down and go over the "McEvoy" plan with him very carefully, asking him from time to time if he understands it. If he says that he does, I say: "Now, I am your student; tell me what to do. When you can tell me what you are going to do, I will trust it to you." In nearly all such cases they have treated it without my assistance, and cured it. I can not recommend anything better than the "McEvoy" plan.

Doctor **Phillips**. There is just one thing I should wish to add to that. The treatment of taking bees from the infected combs was originated in 1769 by Schirach, as nearly as I can find out, and if we are going back to give credit to the originator of this plan, Mr. McEvoy is not the man to get that credit.

Mr. G. W. **York** (Illinois). Was not the plan original with Mr. McEvoy?

Doctor **Phillips**. It was probably original with him, but it was advocated long before in many European works.

Mr. **Smith**. The ground has been thoroughly covered by Mr. France. Two years ago Mr. France said to me: "Now, Smith, I have tried almost everything, but I find the 'McEvoy' plan the best. My advice is to use the 'McEvoy' treatment, as I have done." I have only had one case this year where I have had to make a second transfer, and I found that to be due to infection from a neighbor's colony that I did not get to treat the first time, but which subsequently was treated, and the bees were all right. I have no trouble, and I have great confidence in shaking. I don't alarm the bees. I shall give my method. In treating a diseased colony I use an extra hive, to which the bees are to be transferred, and an additional empty hive, in which I place the infected frames after the bees are shaken from them. The last mentioned is covered with a cloth to prevent other bees from robbing. First I move the old infected hive back, and in its place put a clean hive containing clean frames, with strips of foundation. The frames are lifted from the old hive, shaken in front of the new hive, and then covered up in the third hive, which is used to store infected frames. This is all done in the middle of the day. If there is no honey in the field, the colony should be fed well at night.

Mr. J. Q. **Stone** (Illinois). How do you treat the old hive?

Mr. **Smith**. I either burn out the hive, paint it with kerosene oil and have it burned out, or wash it in strong salt water.

Mr. **Fred Muth** (Ohio). When you shake the bees, they carry over honey, do they not?

Mr. **Smith**. I set the hive right on the ground. I do not jar the frames hard enough to jar out the honey.

Mr. **Muth**. You shake them off during the middle of the day. Is it not better along toward evening?

Mr. **Smith.** If you wait till evening you will never get through.

Mr. **Muth.** Do you use smoke in that operation?

Mr. **Smith.** I use no smoke.

Mr. **Muth.** How long do you keep the bees on the strips of foundation; do you feed them right away?

Mr. **Smith.** Yes.

Mr. **Muth.** You don't believe in starving them at all?

Mr. **Smith.** No, because the bees coming from the fields are loaded with honey.

Mr. **Muth.** Do I understand that the bees have these bacteria all over them?

Doctor **Phillips.** Yes; they have the contamination on them. When they are shaken they of course have it all over them, and when they are shaken off they doubtless take the bacteria with them.

The McEvoy system is the radical treatment of shaking twice, which the majority of bee keepers do not use.

Mr. **York.** If I mistake not, Mr. McEvoy recommends the second shaking.

Doctor **Phillips.** He recommends the second shaking after the bees begin to drop from starvation.

Question. What do you do with the unhatched brood in the infected hive?

Mr. **Smith.** My recommendation is to destroy the whole thing.

EFFECT OF REQUEENING ON DISEASE.

Mr. **Dadant.** Has removing the queens any value in treating the two diseases? Alexander, Simmins, and others have recommended removing the queens. Is this of any value in either disease?

Doctor **Phillips.** As has been stated before to-day, I spent four weeks last spring with the inspectors of New York State in the field. Both American foul brood and European foul brood are found in that State, but practically the same method of treatment is advocated by the inspectors for both diseases. Colonies found to be diseased are shaken according to the method which has been described several times in this meeting.

In order to save any healthy brood which is found in colonies infected with disease, the sealed brood from several colonies, four to eight, is piled up in hive bodies above a weak colony which is diseased. In seven to ten days all the brood which is worth saving will have emerged and the weak colony will have been changed to one strong enough to treat. This colony is then treated by the shaking method as were the others. There is no necessity of waiting more than ten days, for brood which was unsealed when the brood was first attacked will scarcely be fed sufficiently to emerge.

In addition to this treatment, the inspectors recommend the introduction of young, vigorous Italian queens from good stock. It has been shown repeatedly that Italian bees are less liable to disease than most of the black bees, especially of degenerate stock, as is so much of the black stock when no attention is paid to improvement. In a pamphlet issued in 1903 by the inspectors of New York the introduction of Italian brood was recommended. This is not advocated as a cure, however, but merely as a means of protecting the colony against future infection.

Reference has been made to the introduction of Italian queens as a method of curing disease, and to this method the name of Mr. Alexander is attached. In the article in which Mr. Alexander first advocated the plan he says, in part:

> "How to rid your apiary of black brood" (By E. W. Alexander).[a]
>
> This cure is on the line of introducing new blood into the apiary, * * *
>
> Go to every diseased colony you have and build it up either by giving frames of maturing brood or uniting two or more until you have them fairly strong. After this, go over every one and remove the queen; then in nine days go over them again, and be sure to destroy every maturing queen cell or virgin, if any have hatched. Then go to your breeding queen and take enough of her newly hatched larvæ to rear enough queen cells from to supply each one of your diseased queenless colonies with a ripe queen cell or virgin just hatched. These are to be introduced to your diseased colonies on the twentieth day after you have removed their old queen, and not one hour sooner, for upon this very point your whole success depends; for your young queen must not commence to lay until three or four days after the last of the old brood is hatched, or twenty-seven days from the time you remove the old queen. If you are very careful about this matter of time between the last of the old brood hatching and the young queen commencing to lay, you will find the bees will clean out their breeding combs for this young queen, so that she will fill them with as fine healthy brood as a hive ever contained. This I have seen in several hundred hives, and have never seen a cell of the disease in a hive after being treated as above described.
>
> It is not necessary to remove any of the combs or honey from the diseased colony; neither is it necessary to disinfect anything about the hive. Simply remove the old queen, and be sure the young queen does not commence to lay until three or four days after the old brood is all hatched. This treatment with young Italian queens is a perfect cure for black brood.
>
> In regard to those old queens that were formerly in your old hives, I think it best to kill them when you first take them from their colonies—not that the queen is responsible for the disease, for I am sure she is not; but a young Italian queen that has been reared from a choice honey-gathering strain is worth so much more to you that I can not advise saving these old queens.
>
> I have experimented along this line considerably, and found, after the colony has been without a queen twenty-seven days, as above directed, it will usually be safe to give them one of these old queens, and the cure will be the same. Still, there have been exceptions, so I advise killing them at once.

The essential point in the treatment is to allow several days to elapse after the emergence of the last of the healthy brood before the queen begins to lay.

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[a] Gleanings in Bee Culture, November 1, 1905.

There are several points in this treatment and its successful application by Mr. Alexander which may well claim our attention. In the first place, the scales formed by the dried larvæ of European foul brood are less adhesive than are those formed when American foul brood is present. It is therefore easier for the bees to clean out the cells, and in most cases, at any rate, a strong colony would do this. This is one point, then, in favor of the Alexander treatment of European foul brood.

Mr. Alexander's apiary is located in a portion of New York State (Delanson, Schenectady County) where European foul brood has been prevalent for several years. It is a matter of common observation that this disease becomes less virulent in any given locality within a few years, and it is very probable that this plan might be successful in Mr Alexander's apiary and not in localities where the disease is just appearing. At any rate, it is unwise to advocate its use in new regions when there is an established remedy—the shaking method.

The hives used by Mr. Alexander seem to me to have a decided bearing on this subject. They are several inches shorter than the Langstroth hive, and, as a result, in the spring, when European foul brood usually appears, there is not a large supply of honey on hand. This, taken into consideration with the fact that very little honey comes in before August 1 in that locality, is very significant. The hive is not full of infected honey, and consequently when the bees clean out the combs they get all the infected material present. That this method would be successful in a moderate-sized hive—e. g., a 10-frame Langstroth—may well be doubted, for in the twenty-seven days during which the colony is left queenless many cells containing contaminated honey would be left untouched. Either we must advocate very small hives or advise against the Alexander method as a cure.

The New York inspectors say that the publication of the Alexander plan has been a great detriment to bee keepers.

Mr. FRANCE. I visited a yard last year where there were 22 infected colonies. The owner wished to save some new drawn-out combs that were on hives free from the disease. As an experiment we used foundation with half of the colonies and in the others we put the new combs. Eleven had to be treated again, while the others, right in the same yard, did not. You can kill the germs in the honey, but you have to boil it until it is as black as molasses to do it.

Mr. LOUIS SCHOLL (Texas). I do not know that I can say much about treatment in Texas. We do not rely on the shaking treatment at all. Whenever we have had foul brood we have tried something as radical as could be practiced—that is, the burning of the diseased colonies. There is one trouble that we have here in shaking the bees, and that is that if we treat the bees during the honey flow there is so much danger of shaking out the honey and starting the disease again in that way. The other thing with which we have to contend is robbing. During a honey flow there is a good deal of inside robbing almost all the time. Until we find something that is absolutely sure and absolutely a good thing we shall resort to the burning of colonies whenever we find them infected. The way we use the fire treatment is to inspect the yards and then toward evening we dig a pit about 10 feet wide, according to the number of colonies to be treated, and build a brush fire. By the time we have that burning well we go to the colonies that are to be "treated" and use sulphur in a smoker. The entrance is smoked a little, and this kills all the bees. We go from one colony to another to kill the bees. to keep them from leaving the hives in handling; we know that no live bees can escape from those colonies. We remove the combs and burn them, then the bottom boards and the covers are treated over the flames. The hive bodies are stacked on a single bottom board. and from a small can of kerosene we pour just a little oil from the top down the sides; by throwing in some dry grass or anything of that kind, which has been lighted first, the fire will start at the bottom and the hive bodies will act as a chimney. In that way we scorch the hive bodies for a few minutes. As soon as these have been scorched sufficiently we close up the top with a bottom board or cover and close the entrance of the hive with earth; then we leave them for a little while for what we call "steaming."

Mr. ANDERSON. Is there any way of safely detecting American foul brood before the cells are broken, and how long is it after it is sealed before the cap is broken? That is a question I have been discussing at home, and I would like to know if there is a way that it can be detected. For instance, if you have not treated a colony successfully, or suppose American foul brood has been in your locality and you are waiting for it, can you catch it before all the larvæ are exposed?

If there are only two or three diseased cells in a colony and if you cut those out, will the disease go any farther? I have read that if the cell cappings are broken and you take out those particular cells you will never see the disease again in that colony. I have heard an inspector say that he can tell the disease in his own apiary. He claims that there is a way to tell it before the capping is broken, and he says he can take away the disease then and it will not reappear. I know he can, because he has proved it. He can tell where foul brood is before he can actually see it. He further says that the larvæ are killed, but do not show it for forty-two days afterwards. Now, I want to know if anyone else has found such to be the case.

Doctor PHILLIPS. I think his record stands alone.

Mr. **Anderson**. I know this: If you cut this foul brood out before there is another exposure, you won't get it in that colony unless it is carried from somewhere else. I have proved that.

Doctor **Phillips**. As far as the forty-two days' time is concerned, I have no faith in it, because in most cases inside of forty-two days the colony would be dead. I have seen that demonstrated.

Mr. **Holekamp**. I might ask how early can the disease be discovered?

Doctor **Phillips**. Not sooner than the ropiness of the larvæ becomes evident. I never saw a sample of diseased brood from Texas, but, assuming for the moment that the conditions in this State are similar to those in California, the method described in the East is not going to work in Texas. It will work where the disease is not virulent. The same thing holds true for European foul brood. Where it has existed for five years it is easily treated, and the Alexander treatment is sometimes successful, but it is not when the disease first appears in a locality. As you know, European foul brood started in New York and is spreading to the Vermont line. You will find a great difference in the type of disease in Schoharie County and on the Vermont line. The same thing seems to hold in a different way for the American foul brood. The disease is much more easy to combat in the East than in the West. I visited California this summer. Inspectors there have proved to their satisfaction that Eastern methods are not satisfactory, and they told me that it is necessary to burn out the hives. Mr. Smith does not burn his hives, and the inspector in New York does not burn hives; they insist, however, that no honey and no wax cells remain in the hives and that the hives be clean. That does not prove satisfactory in California. We know that this one disease is a very different proposition under different climatic conditions, and in discussing treatment it is necessary to bring out this point. In discussing treatment in bee journals writers forget or do not realize that the plans which they advocate may not do in different places. As Mr. Parker said in his paper, the eastern treatment will cure nine-tenths, but the other tenth has to be taken care of. The disease seems to be much more virulent in the western part of the United States than in the eastern part.

Mr. L. **Scholl**. Our conditions are the same here as in California, I am sure. We have tried some of the shaking treatments, but they were unsatisfactory. On account of the character of the disease here, we think we are on the safe side in using the burning method until we can find something better. While Mr. Smith and others gave their method of shaking the bees, I wish to put the question whether these treatments would work west of the Mississippi River, and that is why we have been practicing such radical measures here. My brother, who is here from the Agricultural and Mechanical College of Bryan, Tex., working for Professor Conradi, has been conducting experiments on this shaking treatment, and you might get him to tell you something about it.

Mr. **Ernest Scholl** (Texas). I am glad to be called upon, because I have been paying close attention to the shaking treatment, and as soon as Mr. J. Q. Smith mentioned his method of shaking but once, I thought surely he is dealing with different conditions or it must have been an accident that he succeeded. My work has been mostly in the northern part of the State, but in one case I had some work in the central part. I thought I would try some experiments. We tried shaking once, but it would not work; the disease appeared just as badly as ever. We tried shaking twice; that worked better, so that shows that shaking once does not work here. I have tried many other experiments, and am still on the go, but this is the only point I want to bring out. Shaking once is not sucessful in Texas, and I don't think it ever will be. I don't see how Mr. Smith can be successful in treating, because the bees gorge themselves with honey. Down here, as soon as you open a hive the bees will run to the cells and, consequently, shaking once would not work; and, as my brother said, there is always some honey taken up and the bees carry it into the new hive.

Mr. **Juneau**. Mr. Smith's plan is satisfactory in Colorado. We shake our bees there, but we smoke them a little bit and we shake only when a honey flow is on. The honey will sometimes drip on the wings of the bees, but it is very seldom that foul brood starts again. I have been an inspector there for a number of years, and the general way is to shake the bees hard. We shake them a little bit differently. We put paper down and we shake when the honey flow is on and we save nearly all the brood—that is, the healthy brood—and let it stay twenty-one days. The reason for letting it stay so long is because there is honey around and the bees hatching out will use it. Not only do the inspectors instruct that shaking be practiced, but the State association has issued pamphlets, in which this treatment is explained, to be given by the inspector to each man who has foul brood.

Mr. **D. C. Milam** (Uvalde County, Tex.). In our locality we are governed by conditions. If the conditions are not favorable for shaking, we burn the bees, frames, and all. If the conditions are favorable, shaking is all right. Last May I shook five colonies in one apiary for experiment, and week before last I went there and they were all right, but honey was not coming in fast.

I wish to speak of another thing. In this apiary I watched especially to see if there was any disease of the unsealed brood and I found none. Two years ago I found the disease both in the sealed and unsealed brood, and the question comes up: Have we both diseases, the European and the American foul brood? I began to hunt for another disease attacking sealed brood, and I found it that year; but I looked further, and in 65 colonies which I shook off last spring you could not find disease in any unsealed brood. Last fall a year ago I went to one apiary that had several colonies in which the sealed brood was diseased. I told the family what they could do. I said: "You will either have to fight this disease and take care of the colonies through the winter or you can burn them up." I will say they were not bee keepers, and they said just to burn up everything. I agreed to this, but said that there were two colonies in the apiary that had only a few cells diseased, and I would experiment on them—that I would take them under my own management. I burned the rest, but I kept those two colonies until this spring. This spring they became weak and I set one colony on top of the other. Last week I went back there, although I had examined them some time ago, and they had starved to death.

One shaking, I am sure, will do under favorable conditions, but if the bees are not gathering honey, I would not advise shaking.

MEDICATION.

Mr. DADANT. Has anyone ever tried feeding medicated sirup? The reason I ask the question is because some people succeed with drugs.

Mr. SMITH. Mr. Reynolds was the first man in Illinois who imported Italian queens. He said that after foul brood got into his bees and destroyed them he heard of a remedy that could be obtained at the drug stores, and the next time he transferred his bees he used this and he had good luck with them.

Mr. DADANT. After shaking them?

Mr. SMITH. Yes, sir; and he ordered some of this drug from St. Louis just a short time ago. He said he was going to feed it to the bees next spring for fear they would develop the disease again.

Mr. UDO TOEPPERWEIN (Texas). It is a good idea to feed the bees sugar and naphthol beta.

Mr. ATCHLEY. As Mr. Scholl has already stated, I don't believe treatment will eradicate foul brood in Texas. I have seen a few people that have experimented this season in shaking bees. We have never been able to determine results in shaking in one season. I have had the disease disappear in the summer and fall and the next year the colonies would be diseased again. Another point, in Texas bees are too cheap to treat. We can burn them and buy other colonies to replace them with less expense.

PICKLE BROOD.

Mr. **Smith**. Is there anyone present whose bees have been suffering from pickle brood?

Mr. **Dadant**. Mine have, and I used oil of eucalyptus. I thought I had foul brood and I afterwards discovered that it was pickle brood. About every four days I fed some oil of eucalyptus and in three weeks there was no trace of the disease.

Doctor **Phillips**. Would not that disease have disappeared without the use of drugs?

Mr. **Dadant**. I doubt it. I asked another bee keeper to try the same thing and the result was the same.

Doctor **Phillips**. We have no proof that pickle brood is at all infectious. Oil of eucalyptus is a disinfectant; therefore I was wondering what effect it had.

Mr. **Holekamp**. One of the members of the Missouri State Bee Keepers' Association, who was about 20 miles from St. Louis, asked me to come over and help with his bees. He said last spring that his bees were in a terrible condition; he was very busy and did not know what to do. A good many of the colonies were in bad condition. He put a tablespoonful of carbolic acid in a quart of water and sprinkled his bees with this. He told me they were all well except two colonies. He said he did not look at them. I looked at them and they were clean. He told me that he had colonies that had gathered in five days a super full of honey. He had about 10 square miles of Spanish heather, but these colonies that had been affected did not make any surplus, so there must have been some disease.

Doctor **Phillips**. It might have been pickle brood. Pickle brood is sometimes pretty bad, but it will disappear.

EXPENSE OF TREATMENT.

Doctor **Phillips**. Is it so expensive to treat bees? How much does the colony lose by shaking during the honey flow?

Mr. **Anderson**. We lose a honey crop. Take all that brood away from a colony and all that remains is the live bees. For ten days there is no brood started to take the place of what has been removed.

Mr. **Juneau**. It is altogether different in our country (Colorado). We shake bees, and they act just like a new swarm. I have had as high as two or three swarms from those that have been shaken, if they were ordinarily good strong colonies, and I believe it will do just as well to shake a colony during a honey flow as any time. It makes no difference.

Doctor **Phillips**. That is the point I was about to mention. I know that in Colorado they sometimes shake bees whether there is disease or not, because they claim the bees do better. You talk about shaking bees being a very expensive operation, but you do not need any brood during the honey flow, and the time makes a great difference.

Mr. York. There is one thing to be taken into consideration. Bees are worth less per colony in Texas and California than in the East. When you talk to a man here about burning 30 colonies, it does not take all his bees.

Dr. Phillips. I do not know about Texas, but I do know that farther west an eradication of 50 colonies to many of the bee keepers of the West is not a serious proposition. The western bee keeper's normal increase is more than his loss, so it is not like the loss to a small bee keeper.

Mr. Atchley. In Texas we hardly ever find an apiary in which every colony has the disease; therefore, when we burn the affected colonies we have enough left to rebuild the apiary.

Mr. Rankin. In considering this matter of bee disease and bee inspection one sometimes wonders if the ideal inspector exists. It would seem that bee inspectors are born, not made. The fact that a man knows bee disease and its treatment does not indicate that he is necessarily a good inspector. The most successful inspectors of whom I know are men who not only know bee disease thoroughly, but also have the ability to handle the bee keeper whose bees they are inspecting. The successful bee inspector, then, must first of all be able to diagnose the disease and know it under all its varying conditions. Next, he must know its treatment and management under every condition which may arise; he must know every condition on which the success of the treatment depends. Then, last, but also of vital importance, he must be able to use tact in the handling of the men whom he is appointed to help. He must know from the appearance of a man and from the first words exchanged just how to proceed with that particular individual to secure the best results.

Let me add a word in defense of the inspectors. I know 14 of those in California personally, and among them are some very exceptional men. They are not all equally successful, although I believe they all know bee diseases thoroughly, but among the entire number I do not know a single man who is serving as bee inspector merely for the money he receives for the work. Let us give credit to whom credit is due. These men are doing good work, and it is through these men that the bee keepers must look for the suppression of bee diseases under the present system. Give them your support and encouragement, but never under any consideration criticize them in public in a way which would interfere with the work on bee disease. The laws provide for the removal of an incompetent man, and if a man is not competent to serve as an inspector let him be removed and a man put in his place who is competent, but under no circumstances subject an inspector to the criticism of the bee keepers of the community or of the bee-keeping press. This is unwise, for it gives the public a prejudice against inspection rather than against the individual inspector, while those few deserving of censure are perhaps unaffected.

BOILING HONEY FROM DISEASED COLONIES.

Mr. **Muth**. Mr. France has said that you can not kill the germs in honey until you boil and boil until the life is all out.

Mr. **Rankin**. All you have to do is to make a hot fire and the honey will boil. Of course you have got to boil it sufficiently long to kill the germs.

Mr. **Muth**. How large is the tank reservoir?

Mr. **Rankin**. Big enough to hold your combs; as Abraham Lincoln said of your legs, they must be long enough to reach the ground. The tank used by one bee keeper is 6 feet square and 4 feet high, and you would be surprised to see the amount it will take care of.

Mr. **Theis** (Wis.). Are the frames destroyed then?

Mr. **Rankin**. Yes; we never use any secondhand frames.

Mr. J. A. **Rouse** (Mo.). I would like to ask if that water does not get too thick?

Mr. **Rankin**. Not at all.

Mr. **Rouse**. How do you get rid of the honey? I tried that plan and found that honey and wax hung with the frames until they did not look like frames.

Mr. **Atchley**. Mr. Rankin's treatment is similar to ours except that we burn. The labor for digging ditches is very cheap. It would only cost us $5 to get ten ditches, and in each ditch we can burn 30 or 40 colonies. Our treatment is something like your California treatment, except that it is not so complicated and is less work.

Mr. **Rankin**. That is another phase of the proposition. Conditions are different in that also. In California you can not hire a man to do the work for less than $80 per month.

Doctor **Phillips**. We have gone over the subject of treatment thoroughly, and I think all persons here have arrived at about the same conclusion; that is, that it will not do for a man who has a few colonies in one part of the United States to write to our bee journals and tell us all what to do. We want to know what he is talking about. The vast majority of the men who write to-day know nothing about the varying conditions. What will work in one little county in the East will not work in the West, and vice versa, the methods of the West will not work in the East. Suppose that Mr. Scholl should sit down here and tell everybody in the United States to burn their bees.

Treatment depends upon the locality. Locality is an important factor, but what we have to do is to find out in what respect the locality is different, whether it is in climatic conditions or in the conditions of the honey flow. We are in just as much ignorance when we attribute difference to "locality" as if we did not recognize any difference. We must get down to the point where we know the individual factors involved. I anticipate that when some of the discussions that have been carried on this afternoon are read, they will open the eyes of some people that think they have had some experience with disease. We have men from the East and West who have different conditions to contend with. That is one reason why I have been in favor of an inspectors' meeting. Here we get on a common ground. Conditions from different parts of the country are discussed in a way that you can not obtain practically in any other way.

I have copies here of the laws relating to foul-brood inspection now in force. Some of these are deficient and others have valuable points which ought to be brought out. It seems that the best thing to do is to put a copy of them in the hands of every man who is an inspector, with a list of questions taking up the points which are covered by the laws, and ask each one to express an opinion concerning them. Then all that expert testimony should be collected and put on record, so that people interested in future changes of legislation may read it. If there is anyone here that would suggest how this subject should be handled, I should like to hear from him.

After some discussion, it was finally decided that the Bureau of Entomology be asked to prepare a list of questions to be sent to all the inspectors. (The future action in regard to this is discussed in the preface).

Mr. France then read the following paper:

THE HISTORY OF BEE DISEASE INSPECTION IN WISCONSIN.

By N. E. France,
Inspector of Apiaries for Wisconsin.

From 1870 to 1886 bee keeping was one of the profitable agricultural pursuits in Wisconsin. There was no limit to the bee pasturage of white clover, besides miles of basswood timber and large areas of wild flowers. Comb honey in all kinds of packages sold for from 25 to 30 cents a pound, queen bees for from $3 to $10, and full colonies were from $10 up.

In 1886 one Wisconsin bee keeper received $10,000 in cash from his 1,400 colonies, and started the first bank of Jefferson, Wis. Another apiary of 250 colonies yielded in 1882 29,000 pounds of honey; in

1884 30,000 pounds, and in 1886, with 240 colonies, it yielded 25,000 pounds. This bee keeper also became a partner in a bank. Another apiary of 175 colonies in 1886 yielded 32,725 pounds of honey and in 1891 the bees were all dead with foul brood. Another apiary of 200 colonies in 1900 yielded 21,000 pounds of honey, but in 1904 all the bees were dead. Another apiary of 50 colonies in 1897 yielded 3,500 pounds, but in 1900 all the bees were dead. Another apiary of 26 colonies in 1899 yielded 2,500 pounds of honey and in 1901 all the bees were dead. Thus I could enumerate a pageful of similar sad results of foul brood.

About this time the State Bee Keepers' Association voted to delegate to the president of the association the securing of proper laws for the eradication of this disease. With little help from the bee keepers, he had to see his efforts turned down. Two years later I was delegated as before, but without the personal help of our members the bill was ridiculed and lost. While before the legislative committee I learned better what must be done, and two years later a committee of all the officers of the State Bee Keepers' Association was delegated to act, with the promise that each State member would do his part. The committee got figures of facts about Wisconsin bee keeping and furnished each association member with copies of the same, with the request that each one see personally the member of the legislature from his district. Many members did as requested and our entire committee appeared before the first legislative committee and made good progress. When the last State committee on State appropriations was to consider our bill I was alone. Several other bills calling for aid were turned down before I had a hearing. I gave the committee these facts to consider: (1) There are 10,535 farms in Wisconsin, having 106,090 colonies of bees, which produce in one year 2,677,100 pounds of honey. (2) There are more than twice as many pounds of honey produced each year in Wisconsin as there are head of cattle or sheep. (3) One year's honey crop in Wisconsin would load 13 freight cars, or if placed all in full-weight pound section boxes, touching each other, a sweet honey walk 4¼ inches wide would reach 181¼ miles—more than the distance across the State. (4) The valuation of Wisconsin bees and products amounts each year to more than the appropriation made by the State for several State institutions. (5) The State Horticultural Society receives over ten times more aid from the State than the bees do, yet over three times as many pounds of honey as bushels of apples are produced. (6) Over 10,500 Wisconsin taxpayers and voters who send representatives to the legislature are bee keepers and ask to be reasonably protected by law to save the bees.

After I was excused from the committee room the committee voted unanimously to recommend the bill for passage. It soon became a law, and an inspector was appointed in the person of the writer. Owing to false statements in the papers regarding the new office created, I met with all kinds of difficulties, such as being met at the gate with a shotgun and bull dog. At other times I was ordered from the premises with a pitchfork raised over my head, but each time I quietly explained why I was there, what I intended to do, and read the law, "or refuse to allow the inspector of apiaries to inspect such apiary, honey, or appliances shall be fined not less than $50 nor more than $100, or be imprisoned in the county jail not less than one month nor more than two months." Before going away I saw the apiary cleaned up in proper shape, the owner well pleased, and was requested, whenever in that part of the State, to call and see them. Now, when I am called to inspect or treat an apiary the bee keeper is glad to leave his other work and meet me at the train, take me to the desired place, help me, and even take his team to aid inspecting the neighborhood. Everyone who has once been through the treating process will never need State aid again, but will take care of his own bees in the future.

Several times the disease has been almost stamped out of Wisconsin, when newly imported cases have appeared, and before owners know what the trouble is several apiaries are affected. I hope that soon every State will have laws on diseases of bees, and that no one can sell or ship bees without a health certificate similar to that required for farm stock in Wisconsin.

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